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8.0 ACCIDENT ANALYSIS

Previous sections have identified and discussed features important to safety (ITS). This section identifies and analyzes a range of credible and non-credible accident occurrences (from minor events to design basis accidents). They include normal and off-normal events and accident design events identified by American National Standards Institute/American Nuclear Society (ANSI/ANS) 57.9, as applicable to the Idaho Spent Fuel (ISF) Facility. U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 3.48 specifies that the four event types in ANSI/ANS 57.9 be addressed (Refs. 8-1 and 8-2). Design Events I and II consist of normal and off-normal events expected to occur routinely or to occur approximately once per year. Design Events III and IV consist of infrequent events and postulated accidents that might occur over the lifetime of the ISF Facility, or hypothetical events postulated because their consequences may result in the maximum potential impact on the immediate environment. The generic off-normal events and accidents identified in NUREG-1567 and facility-specific events are included in the overall scope of this chapter (Ref. 8-3).

Design Events I include those that would be expected to occur during normal operations. See Chapter 5, *Operation Systems*, for a discussion of normal operations, which are Design Events I. Sections 8.1 and 8.2 of this chapter analyze events defined as off-normal and accidents, respectively. Section 8.3 discusses site characteristics that affect the safety analysis. Section 8.1 is subdivided into ISF Facility processing scenarios, to identify the off-normal events by the process in which they are postulated to occur. Each event is systematically analyzed by considering the postulated cause of the event, detection of the event, analysis of effects and consequences, and recovery and/or corrective actions.

Section 8.2 is subdivided into categories that identify the accident as a general area-related event or as an ISF Facility process-related event as in Section 8.1. Each accident is systematically analyzed by considering the cause of accident, accident analysis, and radiological consequences.

The conservative assumptions and methods used in the analyses of off-normal and accident conditions represent an upper bound for the ISF Facility design basis events. The analyses demonstrate that the ISF Facility satisfies the applicable design criteria and regulatory limits. Therefore, the reported values of parameters, such as temperatures and stress levels, envelop the values that would actually be experienced for the various postulated accident conditions.

8.1 OFF-NORMAL EVENTS

This section addresses Design Events II from ANSI/ANS-57.9-1984. These events include those that might occur with moderate frequency, on the order of once during any calendar year of operations.

The structural analysis of the ISF Facility for normal operations considers anticipated loads from spent nuclear fuel (SNF) storage and handling operations, in combination with normal variations in external temperature, humidity, wind loading, rain, snow, and other environmental extremes. See Chapter 4, *Installation Design*, for a discussion of the design features for these normal operational considerations.

Design Events II include Transfer Cask events, fuel storage events, waste handling events, and other events. The off-normal events identified in this section were selected as the bounding cases for the larger population of credible events identified during design of the facility. The radiological impacts from these off-normal events are summarized at the end of this section.

8.1.1 Transfer Cask Events

8.1.1.1 Misventing of Transfer Cask

Postulated Cause of Event

After the Transfer Cask is received in the Cask Receipt Area it is placed on the cask trolley and moved into the cask decontamination zone of the Transfer Tunnel. Here the cask atmosphere is vented by attaching the cask vent to a portable continuous air monitor (CAM) and flammable gas monitor. The cask atmosphere is filtered, monitored, and released through the CAM to the building HVAC system. Misventing of the Transfer Cask atmosphere to the cask decontamination zone environment has been postulated to occur as a result of operator error or equipment failure.

Detection of Event

The misventing event would be detected by direct operator observation and radiation monitoring equipment in the cask decontamination zone. Health physics monitoring provides additional means of detection. The specific radiation monitoring that would detect this event are the fixed area radiation monitors (ARM) and CAMs. Placement of these detectors will be optimized within the facility to detect a postulated release.

Analysis of Effects and Consequences

Before transport to the ISF Facility, the Transfer Cask is loaded under atmospheric conditions. The potential for a pressure increase during transfer to the ISF Facility is addressed in Appendix A of the SAR.

Flammable hydrogen gas can be formed by the radiolytic decomposition of moisture in either the fuel or the Transfer Cask cavity. The maximum decay energy load in the Transfer Cask will be up to 90 TRIGA elements, with a decay energy of 2 (J/s)/Element. The ability of aqueous radionuclide solutions to generate hydrogen gas has been extensively studied (Ref. 8-4), and “G-values” have been developed to relate decay energy to hydrogen gas production. For beta and gamma irradiation of pure water, the reported G-value is 0.44 molecules/100eV (4.57×10^{-8} mol/J). Note that this G-value assumes that all of the decay energy is absorbed by the water and is used to generate hydrogen. The amount of energy actually expended in radiolysis is dependent upon the energy spectrum, geometry, and the materials involved in energy absorption, but is typically a fraction of the total decay energy.

The rate of hydrogen generation within the Transfer Cask, assuming that 100 percent of the decay energy generates hydrogen gas, is given by the relationship:

$R = (\text{Decay Energy})*(G) = [90 \text{ Elements}]*[2(\text{J/s})/\text{Element}]*[4.57 \times 10^{-8} \text{ mol/J}]$
$R = [8.23 \times 10^{-6} \text{ mol/s}]*[22.4\text{L/mol}] = 0.0002 \text{ L/s at } 273°\text{K and 1 atm pressure}$

The fuel cavity of the Transfer Cask is approximately 26 inches in diameter by 158.5 inches long, for a volume of 84,152 cubic inches [$=3.1416*(26/2)^2*158.5$], or 1,380 liters. The ISF canister used to ship the TRIGA fuel is approximately 18 inches in diameter by 130 inches long, for a total volume of 33,081 cubic inches [$=3.1416*(18/2)^2*130$], or 542.5 liters. Therefore, the void volume of the cask (assuming that any other cask internals are of negligible volume) is approximately 837.5 liters [=1,380 – 542.5]. The lower flammability limit for hydrogen is 4 percent by volume; therefore, to generate a flammable atmosphere, approximately 33.5 liters [=(0.04)*(837.5)] of hydrogen must be generated.

Assuming that approximately one-third of the decay energy contributes to radiolysis, the time required to generate a flammable hydrogen atmosphere within the void volume of the cask is:

Time = (Void Volume)/(R/3) = (33.5 L)/[(0.0002 L/s)/(3)] = 502,500 seconds
Time = (502,500 seconds)(min/60 s)(hr/60 min) = 139.5 hours, or 5.8 days

The ISF is designed to receive, unload, and return the Transfer Cask within 48 hours. It is highly unlikely that fuel will remain within the Transfer Cask for the period of time required to generate a flammable atmosphere within the cask. Therefore, flammable atmospheres within the cask are not anticipated, nor considered further in this analysis.

After the Transfer Cask is received, the cask is moved from the Cask Receipt Area into the cask decontamination zone of the Transfer Tunnel. Here, the cask venting equipment is used to sample the Transfer Cask atmosphere, and establish the levels of airborne contamination that are present. Failure to properly secure the cask venting equipment connection before opening the Transfer Cask vent valve, or equipment failure, would result in a bypass of the cask venting equipment and a venting of the contents directly into the cask decontamination zone. The SNF canister within the Transfer Cask provides a contamination control barrier for each fuel type received at the ISF Facility. The Transfer Cask venting system obtains a sample of the space between the spent fuel canister and the interior of the Transfer Cask. As a result of this physical arrangement, ordinary radiation control procedures, and the ambient temperatures involved, the most significant source of worker exposure from misventing the Transfer Cask space would be gaseous radionuclides.

The assumptions used in analyzing this off-normal event include:

- Workers are assumed to be exposed to the gaseous “cloud” for 10 minutes.
- Thirty percent of the fission gases present in one fuel element are released.
- The radioactivity release is into a semi-infinite cloud with a radius of 4 meters (conservative based on normal ventilation mixing).

For the fuel types handled at the ISF Facility the gaseous radionuclides present that would contribute dose to a worker are ^{3}H, ^{85}Kr, and ^{129}I. The fission gas release assumptions are consistent with NRC Interim Staff Guidance 5, assuming that the off-normal occurrence is related to a venting problem and not fuel damage. The reference man (worker) breathing rate of 3.33×10^{-4} m^3/s is used in accordance with Title 10 Code of Federal Regulations (CFR) Part 20 (Ref. 8-5).

A worker near the cask would receive a dose based on inhalation of the contaminated atmosphere. The worst-case fuel type results in a total effective dose equivalent from the gaseous release of less than 10 mrem. This value is well below the 10 CFR 20 occupational dose limit of 5000 mrem/year (Ref. 8-5). Dose to the public at the controlled area boundary assuming a ground release of the above inventory is negligible, based on the minimal impact on operators at the source of the release. Normal ventilation flow is designed to minimize air leakage from the cask decontamination zone to the environment. In addition, if a release from the area did occur, the dose to the public at the site boundary would be dispersed considerably compared to the local dose to operations personnel.

This event involves no change to the fuel or structural integrity configuration; therefore, there is no change in criticality control parameters, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

Venting operations would be terminated and the cask decontamination zone would be recovered/decontaminated according to established procedures. Doses to workers from this recovery activity are assumed to be significantly less than those for the event, and on the order of those associated with routine facility operations. Cause analyses, as needed, and appropriate corrective actions to prevent recurrence would take place under the ISFSI Quality Assurance Program.

8.1.1.2 Transfer Cask Drop Less Than Design Allowable Height

Postulated Cause of Event

The cask receipt crane and interfacing lifting devices are designed to be in compliance with the guidance contained in NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants, Resolution of Generic Technical Activity A-36*, (Ref. 8-6). Appendix A of this Safety Analysis Report (SAR) discusses the Transfer Cask lifting trunnions compliance with NUREG-0612 criteria to ensure an uncontrolled drop is not credible. The drop of the Transfer Cask during handling is not considered a credible event.

Detection of Event

Dropping the Transfer Cask during handling is not considered a credible off-normal event.

Analysis of Effects and Consequences

The cask receipt crane and interfacing lifting devices are designed in accordance with the guidance contained in NUREG-0612. The cask receipt crane is designed in accordance with NUREG-0554, *Single-Failure-Proof Cranes for Nuclear Power Plants* (Ref. 8-7). The cask lifting device is designed as specified in ANSI N14.6-1993, with the more conservative design margins specified in NUREG-0612 applied (Ref. 8-8). The Transfer Cask trunnions evaluation for meeting the design margins specified in NUREG-0612 is provided in Appendix A of this SAR. Therefore, dropping the Transfer Cask during hoisting operations is not considered a credible event.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change in criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

Dropping the Transfer Cask during handling is not considered a credible off-normal event; therefore, no recovery or corrective actions are required.

8.1.2 Fuel Packaging Events

8.1.2.1 Attempt to Lower Fuel Container into Occupied Fuel Station

Postulated Cause of Event

SNF handling operations will be under administrative control and records of loading pattern/status will be continuously updated. This event assumes that an operator attempts to load a full SNF container into a fuel station occupied by another full fuel container. This event is postulated to occur as a result of operator error.

Detection of Event

This event would be detected visually by operators when the load ceased to descend, via load indication at an operator control station, and/or via trip of the fuel handling machine (FHM) hoist on a slack rope condition.

Analysis of Effects and Consequences

An attempt to lower a fuel container (DOE basket, ISF basket, or canister) into a fuel station (Fuel Packaging Area [FPA] bench containment vessel or trolley) already containing a loaded fuel container is unlikely. Fuel handling activities are visually monitored via operator station shield windows and a video camera mounted on the power manipulator system (PMS). Procedures for fuel handling activities will require fuel accounting and visual confirmation that planned movement destinations are not occupied before lowering a fuel container into a fuel station.

FHM design features minimize the potential for damage to a DOE basket, ISF basket or SNF as a result of impact during this event. The FHM hoist speed is variable within a range of 0.5 to 14 feet/minute. To ensure that fine alignment adjustments can be made to prevent interferences, the FHM hoist would be operated at creep speeds during the final descent when SNF elements or containers approach a fuel station or container. Even at the FHM hoist maximum descent speed, the impact during this postulated event is not expected to significantly damage the fuel container as shown below. The DOE baskets and containers ability to withstand postulated impacts is addressed in Appendix A of this SAR.

The ISF baskets have been analyzed for normal lifting operations (dead weight with a 1.15 dynamic factor) lifting through the basket pintle. As part of the storage seismic event, the ISF baskets have been analyzed for 10g acceleration while contained in a rigid structure (storage tube, CHM body, canister cask, or fuel loading station). A conservative method of analyzing for sudden impact is provided in *Roarks Formulas for Stress and Strain* (Ref. 8-9). For an elastic impact of a bar onto a hard unyielding surface, the duration of impact is based on the velocity of the resultant stress wave.

Vs (stress wave velocity) = 68.1 x [Modulus of Elasticity (lb/in^2) / Density (lb/ft^3)]$^{0.5}$

Time of impact = [2 x bar length (ft)]/Vs (sec) (Note: Typically 1 to 10 milliseconds for an impact event)

Deceleration = Initial bar velocity (ft/sec)/Time (sec)

Using a Modulus of Elasticity for steel = 29 x 10^6 lb/in^2; Density = 489 lb/ft^3; Initial Velocity = 14 fpm (0.0233 ft/sec); and Basket and Lifting Device Nominal Length = 9 ft to 20 ft (use 9 ft as conservative length), then

$Vs = 68.1 \times (29 \times 10^6 / 489)^{0.5} = 16{,}600$ fps

Time = (2 x 9)/16,600 = 0.0011 sec (Note: 1.1 milliseconds is conservative for typical impact)

Deceleration = 0.233/0.0011 = 215 ft/sec^2 or 6.7g

The ISF baskets have been analyzed for a 10g seismic loading, without exceeding ASME code allowables; therefore, the postulated impact deceleration of approximately 6.7g will not affect the basket structural integrity.

The criticality implications of this event have also been considered. Reflector material and other structural elements contained in the upper and lower regions of each spent fuel element type, would prevent neutronic coupling of the fuel elements if the fuel containers were configured as postulated in this event (stacked axially). The criticality analyses examined one TRIGA basket on top of another, one TRIGA canister on top of another, and one Peach Bottom canister on top of another. The Shippingport modules are not enriched and the lack of appreciable amounts of fissile material ensures criticality safety without further limiting control of the geometry or neutron absorbing poisons. The bounding criticality analyses are discussed in Section 4.7.3.4 and Section 4, Appendix 4A. These bounding analyses show that k_{eff} for the various fuel types would remain below 0.95 for the postulated events.

This event occurs within the FPA, which provides confinement for the fuel. The lack of structural deformation will ensure retrievability of the DOE baskets, ISF basket, or canister. Therefore, there are no significant radiological consequences from this postulated event.

Recovery and/or Corrective Actions

In the unlikely event that a significant impact occurred during this event, recovery would require inspecting and evaluating the ISF basket, canister, and lifting devices for damage to ensure that it would remain within its design basis for the life of the facility. Recovery may also require transferring the fuel to another fuel basket. The cause of the condition will be determined and corrective action taken to preclude further occurrence under the ISFSI Quality Assurance Program.

8.1.2.2 Attempt to Load Fuel Element into Full ISF Basket

Postulated Cause of Event

Fuel elements will be transferred from the DOE containers to the ISF baskets within the FPA. The operator will manually align each fuel element into the proper location within the ISF basket. This event is postulated to occur as a result of operator error during the transfer process.

Detection of Event

This event would be detected visually by operators when the load ceased to descend, via load indication at an operator control station, and/or via trip of the FHM hoist on a slack rope condition.

Analysis of Effects and Consequences

An attempt to lower a fuel element into a full ISF basket is unlikely. Fuel handling activities are monitored via operator station shield windows and a video camera mounted on the PMS. Procedures will be established for fuel handling activities requiring fuel accounting and independent verification and visual confirmation that planned movement destinations are not occupied before lowering a fuel container into a fuel station.

FHM design features minimize the potential for damage to an ISF basket or spent fuel element as a result of impact during this event. The FHM hoist speed is variable within a range of 0.5 to 14 feet per minute. The FHM hoist will be operated at creep speeds during the final descent when lowering spent fuel elements or containers into fuel stations or other containers, ensuring that fine alignment adjustments can be made to prevent interferences. Even at the FHM maximum hoist descent speed, the impact is not expected to cause significant damage to the fuel element. Failure of a fuel element during handling is addressed in Section 8.1.2.3.

The potential for criticality is bounded by the postulated addition of a single fuel element, adjacent and parallel to a DOE basket, ISF basket, or canister. The assumed addition of a single fuel element adjacent and parallel to a DOE basket, ISF basket, or canister is addressed by the bounding criticality analyses in Section 4.7.3.4 and Section 4 of Appendix 4A. These bounding analyses show that k_{eff} for the various fuel types would remain below 0.95 for the postulated events.

This event occurs within the FPA, which provides confinement for the SNF. Therefore, there are no significant radiological consequences from this postulated event.

Recovery and/or Corrective Actions

Because no fuel element failure is postulated to occur during this event, recovery actions would be limited to re-hoisting the fuel element, assessing the event, and placing the fuel element in an empty ISF basket or other temporary storage location. Any postulated damage to a fuel container would be addressed within this area such that retrievability would be maintained. The cause of the condition will be determined and corrective action taken to preclude further occurrence under the ISFSI Quality Assurance Program.

8.1.2.3 Failure of Fuel Element During Handling

Postulated Cause of Event

This event addresses the potential for structural or cladding failure of a single fuel element during handling in the FPA. Failure of a fuel element is postulated for several reasons such as operator inadvertently hitting a suspended fuel element with a master/slave manipulator (MSM) or the PMS during inspection activities, inadvertently moving the FHM transversely with the fuel element partially inserted in a fuel container or fuel station, or the element striking an object in the FPA during movement outside the safe load path.

Detection of Event

Operators would detect the fuel failure event by direct observation during handling activities.

Analysis of Effects and Consequences

The FPA has been subdivided into zones which, in conjunction with the FHM programmable logic controller (PLC), are used to enforce administrative controls on FHM movement and operation. These zones include a clearway where maximum FHM transverse speed is allowed, and various activity areas where only FHM creep speed is allowed. These activity areas include locations where SNF and SNF containers are lifted or inserted into a fuel container or FPA fuel station. The creep speed in the long-travel or cross-travel transverse direction is capable of movement with a resolution of 0.1 inch. These controls are enforced by the PLC so that an inadvertent transverse movement of the FHM would likely be quickly identified and halted before damaging a fuel element.

In addition, interlocks limit FHM operation to a single action only. Therefore, during hoisting, transverse movement of the FHM is locked out, further reducing the potential for inadvertent transverse movement.

The MSMs and the PMS in the FPA support various fuel handling tasks. These manipulators are designed for light duty tasks, and are controlled manually. Although not likely, impact of a suspended fuel element during operation of this equipment has been postulated.

The Peach Bottom graphite fuel has a thin sleeve of pyrolytic carbon, which is a higher-density, low porosity nuclear grade graphite around the fuel bearing region of each element. The TRIGA spent fuel is either clad in stainless steel or aluminum. The Shippingport spent fuel is clad in zirconium alloy. A limited number of damaged Peach Bottom 1 fuel elements will be protected by the attached removal tool (ART) used during salvage operations at the Peach Bottom facility. The damaged Peach Bottom 1 fuel elements protected by the ART will be removed from the containers as part of the processing.

Damage to the TRIGA and Shippingport fuel elements from the events identified above are expected to be limited to deformation of the fuel element.

Analysis of this event assumes that a Peach Bottom fuel element fails and breaks into multiple small pieces. Because this postulated event would happen within the confinement space provided by the FPA, no release pathway is credible. In addition, the FPA high efficiency particulate air (HEPA) filters are expected to remain intact, as they are passive components and no credible failure mechanism has been identified as a result of the failure of the fuel element. Therefore, the offsite dose is expected to remain within normal limits.

From a criticality standpoint, the worst-case failure would occur over a fuel container with a full load of fuel. However, reflector material and other structural elements contained in the upper and lower regions of each spent fuel element type prevent neutronic coupling of the failed fuel element with the intact fuel elements. The potential for criticality during this event is bounded by the criticality analyses in Section 4.7.3.4. These bounding analyses show that k_{eff} for the various fuel types would remain below 0.95 for the postulated events. The TRIGA criticality case, where an extra fuel element is added beside the basket full of fuel for maximum coupling, will bound this scenario for the TRIGA fuel. The Peach Bottom criticality case, where an extra fuel element is added beside the basket full of fuel for maximum coupling, will bound this scenario for the Peach Bottom fuel. The Shippingport reflector fuel rods were used to limit neutron leakage from the core and do not contain enriched fissile material; therefore, this fuel type does not require analysis. Because this event would occur in the FPA, dose rates to the operators are expected to remain at normal operational levels due to the confinement provided by this area.

Recovery and/or Corrective Actions

Inappropriate transverse movement of the FHM would be identified visually and halted immediately by the operators. If a fuel element were to fail during handling, operations would cease, and a recovery procedure developed based on the event-specific conditions. Recovery actions would entail the recovery and repackaging of the fuel for loading into an ISF basket. The cause of the condition will be determined and corrective action taken to preclude future occurrences under the ISFSI Quality Assurance Program.

8.1.2.4 Drop of Fuel Element During Handling

Postulated Cause of Event

Single-failure-proof lifting arrangements are provided for the lifting and handling of the Peach Bottom 1 fuel elements, non-instrumented TRIGA fuel elements, and Shippingport fuel modules. The Peach Bottom 2 fuel, the instrumented TRIGA elements, and the Shippingport reflector rods use a friction-grip lifting fixture. These friction grips are described in Section 4.7.3.2.10, *Lifting Device Types 5 and 6*.

The Shippingport reflector fuel rods were used to limit neutron leakage from the core and do not contain enriched fissile material. TRIGA fuel elements are clad with metal (e.g., aluminum, stainless steel) that protects the fissile material. Because the Peach Bottom fuel contains enriched fissile material and does not have a protective metal cladding, it is postulated that a drop could occur during handling which would bound any concern with the instrumented TRIGA elements or the Shippingport reflector rods. Before storage at the INTEC, the top 18 inches of each Peach Bottom 2 fuel element including the lifting attachment were cropped to fit the elements into the interim storage canisters. Removal of the top of the elements does not damage the fuel portion or the remaining length of the element, but does remove the means of providing a single-failure-proof lifting arrangement.

The Peach Bottom 2 fuel elements weigh approximately 84 pounds. A friction grapple will remove the Peach Bottom 2 fuel elements from the Transfer Cask and load them into an ISF basket. However, because this is not a single-failure-proof lifting arrangement, a drop of a Peach Bottom 2 fuel element onto either the FPA worktable or back into the Transfer Cask is postulated to occur.

Detection of Event

Operators would detect the fuel element drop event by direct observation during handling activities.

Analysis of Effects and Consequences

The maximum number of fuel elements that can be involved in this event is 13, assuming that a Peach Bottom 2 element is dropped onto a full DOE canister that contains up to 12 elements of Peach Bottom 2 SNF. If it is assumed the dropped element falls intact across the top of the DOE canister, criticality is not a concern due to a lack of neutronic coupling in this configuration. If it is assumed the element breaks apart and drops into the canister, this configuration is bounded by the criticality model of placing a single additional element along side an array of 18 closely packed elements. Results of this configuration indicate that k_{eff} remains below 0.95. If it is assumed the single element drops onto the work table or floor and the element breaks into multiple small pieces, the criticality analyses show that greater than 21 Peach Bottom 2 elements would have to be crushed and organized into a sphere surrounded and reflected with 1 foot of water before the k_{eff} would approach 0.95. Therefore, postulated configurations for this event will not result in a criticality concern. Offsite and onsite doses are expected to remain within normal limits, because the event would occur within the FPA confinement area.

Recovery and/or Corrective Actions

If a Peach Bottom 2 fuel element were to drop, operations would cease, and a recovery procedure developed based on the event-specific conditions. Recovery actions would entail the recovery and repackaging of the fuel using the FHM hoist, PMS, worktable, and MSMs for loading into an ISF basket. Cause analyses, as needed, and appropriate corrective actions would occur under the ISFSI Quality Assurance Program to prevent recurrence.

8.1.2.5 Fuel Container Binding or Impact During Handling

Postulated Cause of Event

Impact of a fuel container in the FPA is postulated as a result of an operator inadvertently moving the FHM into another piece of equipment or moving the FHM transversely with the fuel container partially inserted in a fuel canister or fuel station. During handling activities in the FPA, it is postulated that a full fuel container (DOE or ISF basket) could hit another piece of equipment when lowering the basket into an FPA fuel station or ISF canister, or during transverse movement of the FHM. It is also postulated that a full fuel container could experience binding during a lift. Binding could result from the introduction of debris into the Transfer Cask or FPA fuel station, or misalignment of the FHM hoist (off-center lift).

Detection of Event

Operators would detect the impact event by direct observation during handling activities. Operators would detect a binding event via observation of FHM load indication or activation of the overload or underload interlocks during the lift.

Analysis of Effects and Consequences

As discussed in Section 8.1.2.3, the FHM is operated via a PLC to enforce transverse movement of the FHM at creep speeds in the vicinity of FPA fuel stations and other activity areas. In addition, cross-travel and long-travel motions are interlocked with the hoist to minimize either type of movement when the hoist is below transport height. Therefore, transverse movement of a partially inserted fuel container sufficient to cause damage is unlikely. In this event operators would halt movement of the FHM. The consequences of this event are expected to be limited to local damage to the fuel container itself. Potential failure of the DOE basket is described in Section 8.2.2.1.

The FHM contains interlocks that prevent a lift from the cask trolley unless the trolley is properly positioned and the locking pins are set, which will minimize the potential for binding. The FHM also contains a load cell capable of determining loads to within ±150 pounds. The operators will monitor the load indicator when raising containers loaded with spent fuel. Therefore, if significant binding were to occur, operators would recognize the increased load at the time of occurrence. In addition, the FHM load cell will trip an interlock that prevents hoisting any load greater than 10,000 pounds. Binding of a fuel container is not expected to cause significant damage to a fuel container.

This event occurs in the FPA, which provides confinement for the SNF. Although, localized container damage may occur, the fuel integrity is not expected to be affected. Therefore, the retrievability and criticality of the SNF is not affected. There are no adverse radiological consequences from this postulated event.

Recovery and/or Corrective Actions

Recovery actions would include suspension of fuel handling activities, visual inspection of the fuel container, and evaluation as necessary. Potential actions could include recovery and repackaging of the fuel for loading into a new ISF basket. The cause of the condition will be determined and corrective action taken to preclude further occurrence under the ISFSI Quality Assurance Program.

8.1.2.6 Malfunction of ISF Canister Heating System

Postulated Cause of Event

This event is the postulated worst-case heating of the ISF canister by the canister heater module, resulting from a failure to regulate the heating during vacuum drying, helium filling, or seal welding. The loss of control on the canister heater module could be caused either by equipment failure or operator error.

Detection of Event

The canister heater module includes temperature monitoring, control, and an alarm on excessive heating or loss of heating. Personnel monitor processing of the ISF canister in the Canister Closure Area (CCA) and out-of-specification temperatures would be noted either by instrumentation or personnel observation before approaching the allowable process limits. Temperature monitoring is a key element in removing moisture, providing the proper atmosphere, and ensuring that the canister is ready for closure operations. The temperature of the canister is one of the controlled process parameters.

Analysis of Effects and Consequences

The canister heater module consists of electric heating elements used to heat the canister cask. Heat is transferred from the heater to the ISF canister and fuel by conduction, natural convection and radiation. The heater design and the large mass of the canister cask ensure that heat-up rates are slow and that the ISF canisters are not subjected to direct heat input or to localized hot spots. The normal canister temperature range for the dry, fill and weld process is from 80°F to 100°F and the maximum allowable clad temperature for the limiting fuel type (aluminum clad TRIGA fuel) is 400°F (Table 4.2-53). Assuming the minimum operating temperatures in the transfer tunnel, and the carbon fuel essentially saturated with water, the maximum heater size required to support required cycle times would be 10kW. Assuming the maximum 10 kW heater, failure or improper operation of the heater would take approximately 48 hours to reach the maximum allowable temperature for the limiting type of fuel. The calculation conservatively assumes that the cask and fuel start at a steady-state temperature of 208°F and the heater remains on until the fuel reaches 400°F. In the unlikely event of equipment failure, 48 hours would be ample time to observe the condition and take corrective action to shut down the heater.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

The heater would be shut down upon indication of the improper heating of the ISF canister by the canister heater module. An analysis would be performed to determine the cause of the off-normal condition. The reason for the high temperature would be identified as equipment failure or operator error. Repair, equipment modification, or other corrective actions would be implemented as appropriate to prevent recurrence of the event. There are no adverse radiological consequences from this postulated event.

8.1.2.7 Malfunction of ISF Canister Vacuum Drying/Helium Fill System

Postulated Cause of Event

The SNF is packaged in a new ISF canister in the FPA in preparation for dry storage. The canister containing the fuel and associated structural/shielding components is transferred to the CCA for installation and welding of the canister lid. The canister is vacuum dried and filled with helium before final seal welding of the canister vent plug. The canister closure and seal welds are leak-tested and the canister becomes the primary confinement boundary for the spent fuel. During canister vacuum drying and helium backfilling, an equipment failure or operator error could result in inadequate drying, a canister atmosphere with insufficient helium, or over pressurization of the canister with helium.

Detection of Event

The vacuum drying system includes instrumentation to monitor the canister pressure and temperature throughout the vacuum drying process. Failure to achieve the required vacuum or fill pressure would be noted immediately. Signals are processed and displayed by the vacuum dry/helium fill monitoring system to visually indicate system status and parameters. Visual indications will alert operations personnel to equipment or process failures or to inadequate parameters. The leak checking operation following final canister seal welding will identify inability to maintain the required atmosphere.

Analysis of Effects and Consequences

The canister vacuum drying/helium fill system including the canister leak check is required to perform the following functions:

- remove moisture from the loaded canister
- vacuum test to verify the canister interior is dry
- provide an inert atmosphere within the canister
- test the leak tightness of the canister lid weld, canister vent plug interim seal and final canister vent plug seal weld

Failure to complete the canister evacuation and inert gas backfill, due to either equipment failure or operator error, could result in an out-of-specification atmosphere in the storage canister, potentially leading to canister oxidation or an increase in the peak fuel temperature. Oxidation of the interior canister wall would be limited because of the small volume of oxidizing gas available and the materials of construction. Although the canister is in an inert environment both internally and externally and is not subject to corrosion, the canister design includes a reduction in wall thickness consideration based on the ISF facility design life. An allowance for corrosion/erosion reduction in wall thickness is provided in the design. It is unlikely that the canister atmosphere would exceed process specifications: failure to achieve the required temperature, vacuum, or backfill pressure would be noted and corrected before further processing of the canister. The quality of the helium is certified by the vendor. If the canister cannot be evacuated a repeat vacuum cycle or replacement of the canister might be required. Once an acceptable vacuum is achieved the oxidizing medium is eliminated unless it is reintroduced during helium backfill. This is unlikely because the process involves achieving the required vacuum, purging the connecting helium line, re-establishing the vacuum, and opening a valve on the pressurized helium line to backfill the evacuated canister with 99.995 percent pure helium. The canister is then evacuated a second time, and the backfill process repeated. Failure to achieve any of the necessary parameters would require repeating the process from the beginning.

Calculations indicate that air vacuum or helium vacuum atmospheres would both be thermally acceptable. The worst-case heat transfer scenario would be an air vacuum in the canister, with no inert gas fill. Calculations indicate that the temperature would rise to a maximum steady-state temperature of 140°F for the bounding TRIGA fuel. This is well below the maximum allowable temperature for the limiting fuel type. The process of repeating the drying and filling of the canister can be completed without exceeding allowable temperatures.

In addition to the vacuum dry/helium fill connection tool pressure devices that measure the gas pressure and temperature during the operation, the helium fill system is designed with a system upper pressure limit equal to the canister design pressure and a pressure relief device that is set to operate at a pressure 10 to 30 percent below the canister design pressure. This ensures that over pressurization of the canister with the fill gas is not credible.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

The recovery will depend on the circumstances that resulted in the incorrect canister atmosphere. The cause of the failure would be determined and the corrective action would be based on that determination. If the cause was an electrical or mechanical failure, the failed equipment would be repaired or replaced and the sequence of operations restarted or completed as appropriate. If the delay were due to operator error, measures would be taken to understand and correct the error and to ensure the error was not repeated. The standard recovery action, regardless of cause, would be to restart or resume the dry and fill operation as required to correct the process failure. There would be no release of radioactive material and no radiological consequences from this event.

8.1.2.8 Loss of Confinement Barrier

Postulated Cause of Event

The event considered is the loss of the Transfer Area confinement barrier for any reason. The barrier includes the FPA and FHM maintenance enclosure walls and doors, shield windows, transfer ports, exhaust HEPA filters internal to the FPA, supply HEPA filters, through-wall penetrations and seals, and specific heating, ventilating, and air conditioning (HVAC) ducts and dampers. These components combine to isolate the radioactive material in the FPA from the occupied areas of the ISF Facility and (potentially) from the environment. Loss of confinement could result from failure of a transfer port seal, penetration of the shield wall or window, failure of an HVAC component, removal of the wrong port cover, or other operator error. The FPA is the only portion of the ISF Facility with the potential for significant radiological release as a result of loss of the confinement barrier. Failure of a confinement barrier provided by the SNF cask or canister is not considered in this analysis. Credible breaches are addressed elsewhere for off-normal or accident events specific to the cask or canister. As the ISF Transfer Area confinement boundary has been designed to withstand the design basis tornado missile, penetration of the shield wall or FPA shield window is not considered a credible off-normal event.

Detection of Event

The control panel visually indicates the status of the HVAC system including the FPA differential pressure and changes in supply and exhaust fan operating parameters. Significant confinement barrier failures would be detected by a sudden change in differential pressure, by changes in an HVAC component operating parameter, or by observation of the HVAC system. If the ISF Facility or system features fail to function as designed, contamination of the adjacent areas would be detected by CAMs, ARMs, and routine area surveys. Significant contamination levels would be readily detected as monitoring instrumentation is set to detect both specific levels and rates of change.

Analysis of Effects and Consequences

The FPA and FHM maintenance areas of the Transfer Area are maintained at pressures negative to the surrounding areas by control of the supply and exhaust fans. The HVAC system is designed to maintain acceptable pressure differentials and cooling air flow for heat transfer. The system ensures that air flows from clean areas to contaminated areas and is exhausted through the HEPA filters. The HVAC instrumentation and control system monitors pressures and temperatures and provides data required to make adjustments. The system is capable of adjusting the supply and exhaust flows to maintain the FPA pressure negative to the adjacent areas. The HVAC system is designed with redundant exhaust fans, each capable of approximately 23,800 cfm with the FPA system sized to exhaust 5900 cfm.

Openings of significant size in the confinement barrier resulting from scenarios such as seal failures would be sensed by the HVAC control system and compensated for by adjustments in the supply and exhaust controls of the HVAC system. Larger openings could occur during repair or maintenance operations such as removal of a wall penetration or barrier component. These types of tasks would be performed under controlled conditions using ISF procedures and an unintentional or uncontrolled breach would be corrected immediately.

A breach of the confinement barrier would most likely occur at the transfer ports during movement of SNF or waste containers into and out of the FPA. As a gap exists between the transfer port and the Transfer Cask or trolley components, the ports between the FPA and Transfer Tunnel are designed with inflatable seals that expand to fill the space. The confinement volume includes the cask inner volume when the plugs are removed and the seals are inflated for transfer operations. The seal remains inflated on loss of power, ensuring that the barrier remains in place during an event requiring safe shutdown of the ISF Facility. Failure of an inflatable seal would result in a maximum opening of approximately 4 square feet, which is considerably less than an open port. Failure of a seal during normal or off-normal operations would not result in loss of area confinement, because air would continue to flow into the FPA enclosure. The HVAC control system would sense a change in the differential pressure and would close the supply dampers to maintain operating conditions. As each ISF exhaust fan is capable of approximately 23,800 cfm and the FPA exhaust system is designed to exhaust 5900 cfm, the available airflow through the FPA would be a maximum of 1475 fpm. The waste ports do not have inflatable seals but open into the enclosed SWPA in the waste area. Any contamination would remain within a controlled area of the ISF Facility. The SWPA doors must be closed before the waste transfer ports can be opened. The waste ports are not opened if active fuel packaging activity is being performed in the FPA.

Opening the wrong transfer port with no cask or canister or no waste vessel in place could result in a maximum opening of approximately 28 square feet. This would have a significant impact on the HVAC system. When the port plug is first removed, room pressure may equalize until the HVAC control system can re-establish the required differential. This could mean a momentary decrease in the velocity of the air flowing through the port into the FPA. As the FPA exhaust system is designed to exhaust 5900 cfm, the available airflow through the FPA would be a maximum of 210 fpm. Air leakage into the enclosure could reduce the flow slightly but the airflow would be adequate to maintain a significant flow into the enclosure minimizing the spread of contamination. At the minimum input air velocity, the most severe consequence could be contamination of the areas immediately adjacent to the opening, but it would not result in a significant release of radioactive material. The areas adjacent to the FPA ports are the transfer tunnel, which is a controlled HEPA filtered environment, and the waste area enclosure, which is a controlled area designed to handle potentially contaminated waste. The HVAC controls ensure that the system airflow is adjusted to maintain the negative pressure differential.

Loss of confinement resulting from failure of an individual HVAC component is not considered likely as the system and components are specifically designed to ensure that the confinement barrier remains intact under postulated conditions and events. Redundant components are provided for the HVAC exhaust system and failure of components such as ducts, dampers, seals etc., would be bound by the inadvertent opening of a port described above. In the unlikely event of component or system failure, the design and fabrication criteria for each component specifically address the features required to maintain confinement barrier integrity.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality or retrievability of the SNF.

Recovery and/or Corrective Actions

In the event of loss of the confinement barrier due to operator error, processing will be suspended, and the barrier will be restored. Cause of the error will be determined and appropriate corrective actions taken. If failure of a transfer port seal occurs, Transfer Area operations will be suspended, the facility put into a safe configuration, the transfer port plug repositioned, and use of the port discontinued until the seal is repaired or replaced. The adjacent areas will be checked for contamination and decontaminated if necessary, using standard procedures. No significant release of radioactive material or increase in exposure is anticipated.

8.1.3 Fuel Storage Events

8.1.3.1 Binding or Impact of ISF Canister During Hoisting/Lowering Operations

Postulated Cause of Event

The ISF canister is lifted into the Storage Area from the canister trolley by the CHM, which also transports and lowers the ISF canister into the appropriate storage tube. The ISF canister is lifted through a port into the CHM and is lowered through the storage tube opening by the CHM. The potential for binding or shearing of the ISF canister was considered in the design of the CHM and interface with the canister trolley. Features on both the canister trolley and the CHM have been designed to ensure that binding or shear of the ISF canister is not credible. The canister trolley and CHM must be seismically restrained to satisfy an ITS interlock on the CHM that will allow the hoist to lift the ISF canister. The CHM must be locked into position and another ITS interlock satisfied for the hoist to function and allow lowering into a storage tube. Therefore, no movement of either the canister trolley or CHM is credible while the ISF canister is being lifted into or lowered from the CHM through the port or storage tube openings.

Impact of an ISF canister within the CHM is postulated as a result of operator error, via inadvertent movement of the CHM into another piece of equipment improperly left on the operating floor. Control devices and associated interlocks that are redundant have been provided to render end-of-travel or building superstructure collisions not credible.

Detection of Event

Operators performing the handling activities would detect the impact event by direct observation.

Analysis of Effects and Consequences

The CHM weighs approximately 380 tons and is designed to withstand seismic events. The maximum horizontal speed of the CHM is 40 fpm. The ISF canister within the CHM during transfer operations weighs less than 10,000 pounds. There are no fixed structures within the operating range of the CHM along the charge face. The largest moveable object is the CHM maintenance trolley that weighs approximately 4.4 tons and is stored outside of the normal CHM travel path. A collision with the CHM maintenance trolley, which has a mass of less than 1.5 percent of the CHM, would not cause a deceleration sufficient to cause the ISF canister to impact the interior of the CHM, due to the low traversing speed of the CHM. The remaining equipment is manually positioned on the charge face and weighs considerably less than the CHM maintenance trolley. None of these obstacles, if hit by the CHM, would create a hazard for the ISF canister secured within the CHM.

This event involves no change to the fuel or structural integrity configuration. Hence, no change in criticality, confinement, or retrievability of the SNF. There are no significant radiological consequences from this postulated event.

Recovery and/or Corrective Actions

Recovery actions would include suspension of fuel handling activities and evaluation as necessary. The cause of the condition will be determined and corrective action taken to preclude further occurrence under the ISFSI Quality Assurance Program. The stress levels imposed by these postulated events would not exceed the design basis allowable stresses. Therefore, no special recovery actions are required.

8.1.3.2 ISF Canister External Contamination in Excess of Limits

Postulated Cause of Event

The event being considered is the radioactive contamination of the ISF canister exterior surface above allowable limits. The contamination could result from incorrect or inadequate installation of contamination barriers, equipment failures, poor housekeeping, or operator error.

Detection of Event

Operations are routinely monitored by fixed radiation sensors and by portable counters to ensure that non-confined areas of the ISF Facility are not contaminated by material, equipment, and personnel moving out of the confinement area or out of potentially contaminated areas. The CCA is equipped with ARMs and CAMs that read out in the operations area and are checked before entering the CCA. Significant contamination levels would be readily detected as monitoring instrumentation is set to detect both specific levels and rates of change. The monitoring will alert personnel to any contamination resulting from inadequate installations, processes, or personnel practices. Excessive external contamination of the canister would be the result of either failure to detect and remove contamination of the weld-prep zone prior to making the weld, or contamination below the weld preparation zone. As part of the canister welding surface preparation, the edge is decontaminated prior to welding and then checked by taking smear samples. If the fixed and portable monitors failed to detect the contamination because of background or distance, the smear sample would indicate unusual weld zone contamination levels and would alert personnel to a potential event. Contamination below the weld zone would also be noted during the testing of the weld zone, as contamination of the canister would occur during the loading process at the top of the canister and be distributed by gravity and contact to the lower canister surface. The subsequent evaluation would quantify the contamination level.

Analysis of Effects and Consequences

The contamination of an ISF canister would occur in the FPA or during transfer to the CCA and would be noted during weld preparation activities. Some contamination is anticipated and will be removed during the weld preparation process. If the canister was contaminated in excess of anticipated limits and the contamination was sufficient to be picked up by the area CAM or ARM instrumentation, the operator would be alerted before personnel could enter the CCA process area. They would enter the area only as allowed by contamination control procedures. If the contamination level was below the threshold of the area instrumentation and contamination and operators entered the CCA, the dose to the operator would be well below the routine dose level from the loaded canister, and accounted for in the procedures. As discussed in Section 7.5.3.12, contamination on the exterior of the canister is limited to 100 dpm/100 cm^2 alpha and 5000 dpm/100 cm^2 beta/gamma. During transfer of the canister and trolley from the FPA to the CCA, any contamination of the ISF canister would be contained within the Transfer Tunnel, and therefore, within the ISF Facility. It would pose no risk to public health and safety. It could require extensive cleanup of the canister and the affected areas and equipment, possibly including the Transfer Tunnel, the canister cask, and the CCA. Decontamination activities could range from manual cleaning of the canister weld surface and adjacent area using swabs and decontamination solutions to establishing a decontamination device or station. The task could require the unloading and replacement, cleaning, or possibly disposal of the contaminated canister.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

An evaluation of the extent of the contamination and cause would be performed. Recovery would depend on the amount, type, and dose levels, and would be performed per standard procedures maintaining exposure and ALARA requirements (See Sections 7.1 and 7.5). Minor contamination of the canister weld area would be removed by hand at the weld station using rags and decontamination solutions. Decontamination of the canister exterior could also be accomplished by setting up a decontamination station. If the canister could not be cleaned to allowable limits, the canister could be unloaded, volume reduced, and disposed of as waste. Following decontamination of the canister cask and repair or replacement of the contamination barriers, a new canister would be loaded with the SNF and operations would resume. Analysis of the cause, as needed, and appropriate corrective actions to prevent reoccurrence would take place under the ISFSI Quality Assurance Program.

8.1.3.3 Extended Operation with ISF Canister in CHM

Postulated Cause of Event

In this event, the ISF canister is left in the CHM for an extended period of time, either because of facility work stoppage, equipment malfunction, or operator error. In any case, the ISF canister is not transferred into the storage tube within the normally allotted time.

Detection of Event

The event would be noted visually by observation of the CHM operation status or by observation of the equipment failure or facility shutdown. The CHM could fail to complete the task, leaving the storage tube open or empty, or could stop before being in position to make the transfer. The operator could stop the operation, and in so doing, fail to complete the task before facility shutdown or shift change, or transfer to another task.

Analysis of Effects and Consequences

The CHM shielding is designed to withstand off-normal temperatures and remain intact. The canister design precludes breach of the canister integrity within the off-normal temperature range. The worst-case scenario would involve heating of the fuel within the CHM as a result of maximum off-normal ambient air temperatures in the Storage Area. The calculation for canister heat-up in the CHM using the Storage Area maximum off-normal temperature of 154°F, indicates that the maximum steady state fuel element temperature is 182°F and the maximum temperature of the hottest CHM component, the CHM guide tube, is 161°F. The temperatures are well within the design allowable fuel, equipment, and facility temperatures.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

The event would be analyzed to determine the cause of the event, and appropriate corrective actions taken. If the repair required an extended period to complete, the CHM could be manually operated to either place the fuel in the storage tube or return it to the canister trolley until the repair or replacement had been completed. As there is no damage to the fuel and no breach of confinement, no release of radioactive material would be anticipated and there would be no radiological consequences.

8.1.3.4 Malfunction of Storage Tube Evacuation/Helium Fill System

Postulated Cause of Event

The SNF canister is placed into a sealed storage tube in the Storage Area vault. The tube is one of an array of vertical storage tubes. The canister containing the fuel and associated structural/shielding components is transferred to the Storage Area after being vacuum dried, helium filled, welded and leak checked in the CCA. The canister becomes the primary containment boundary for the spent fuel during storage. During storage the storage tube provides a secondary confinement barrier. Once the storage tube has been filled with helium and sealed, it is periodically checked for leakage and resealed and recharged as necessary. A malfunction or failure of the storage tube evacuation/helium backfill equipment or an operator error could result in a storage tube atmosphere with insufficient helium or over pressurization of the tube with helium. This evaluation also covers loss of the helium blanket during storage.

Detection of Event

The Storage Area vacuum system includes instrumentation to monitor the storage pressure and temperature throughout the storage tube evacuation process. Signals are processed and displayed to provide visual indications of system status and parameters. Operations personnel will be alerted to equipment or process failures or to inadequate parameters by the visual indications. The loaded storage tube is periodically checked for leakage. Loss of the helium blanket would be noted during the inspection.

Analysis of Effects and Consequences

The storage tube evacuation/helium fill system is required to provide an inert atmosphere for prevention of corrosion. Failure to complete the storage tube evacuation and inert gas backfill due to either equipment failure or operator error could result in an unacceptable atmosphere in the storage tube, leading to canister exterior oxidation. Oxidation of the exterior canister wall would be extremely limited because of the small volume of oxidizing gas available. Although the canister is in an inert environment both internally and externally and is not subject to corrosion, a canister design corrosion/erosion consideration was included based on the life of the ISF facility. An allowance for reduction in wall thickness due to corrosion or erosion was provided in the design. It is unlikely that the storage tube inner atmosphere would exceed process specifications, because failure to achieve the required vacuum or the proper backfill would be noted and corrected before continued storage. The loaded storage tubes are also subject to a periodic inspection during storage to ensure the inert atmosphere is maintained. If the tube was found to be leaking, or could not be recharged because of leakage or internal contamination, the canister would be removed and moved to a new location for storage or rework. Once an acceptable vacuum is achieved the oxidizing medium is eliminated unless it is reintroduced during helium backfill. This is not considered credible because the process involves achieving the required vacuum, purging the connecting helium line, re-establishing the vacuum and then opening a valve on the pressurized helium line to backfill the evacuated canister with 99.995 percent pure helium. The canister is then evacuated a second time, and the backfill process repeated. Failure to achieve any of the necessary parameters would require repeating the process. The quality of the helium is certified by the vendor. Refilling a storage location utilizes the same equipment and procedures.

Calculations indicate that air vacuum or helium vacuum atmospheres would both be thermally acceptable. The worst-case heat transfer scenario would be a vacuum in the storage tube and no inert gas fill. Calculations indicate that the temperature would rise to a maximum steady-state fuel temperature of 168°F for the bounding TRIGA fuel. This is well below the maximum allowable temperature for the limiting fuel type. The process of repeating the evacuation and filling of the storage tube can be completed as required without exceeding allowable temperatures.

In addition to the evacuation/helium fill connection tool pressure device that measures the gas pressure during the operation, the helium fill system is designed with a system upper pressure limit equal to the storage tube design pressure and a pressure relief device set to operate at a pressure 10 to 30 percent below the design pressure. This ensures that over pressurization of the storage tube with the fill gas is not credible.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

The recovery will depend on the circumstances that resulted in the incorrect storage tube atmosphere. The cause of the failure would be determined and the corrective action based on that determination. If the cause was an equipment failure, the failed equipment would be repaired or replaced and the sequence of operations restarted or completed as appropriate. If the delay were due to operator error, measures would be taken to understand and correct the error to ensure that the error was not repeated. The standard recovery action would be to restart or resume the operation as required to correct the process failure. No release of radioactive material and no radiological consequences are anticipated.

8.1.3.5 Partial Air Inlet/Outlet Vent Blockage

Postulated Cause of Event

This event is the partial blockage of the cooling air inlets and/or outlets for the Storage Area vaults. The air flows into air inlet vents, through annular openings around the individual storage tubes, and out through outlet vents in the upper portion of the Storage Area. Blockage may be caused by unusual weather conditions (snow and ice accumulations, wind driven debris, etc.) or by personnel error (inadvertently covering or blocking the openings). Any of these conditions could partially block the Storage Area vent paths.

Detection of Event

Building inlet and outlet vent blockage will be detected by routine surveillance, including required surveillance inspections after adverse weather, such as heavy snowfalls or extreme winds. Blockage of the annular openings around the storage tubes would be detected by observation during storage operations or routine surveillance. The frequency of this monitoring is based on identifying an overheating condition caused by blockage of the vent air flow in sufficient time to take corrective actions. Partial blockage of the building inlet or outlet vents or the annular vent openings sufficient to be of concern would be noted well in advance of reaching maximum allowable fuel temperatures. Therefore, any significant partial blockage would be readily detected by observation during routine surveillance activities with adequate time to take corrective action.

Analysis of Effects and Consequences

The ISF fuel storage system is a vault configuration with co-located storage tubes rather than a more typical cask on a storage pad. The ventilation system is designed with multiple separated and elevated inlets, cooling paths around each storage position, and elevated exhaust vents. Multiple paths are available for heat transfer in the event of individual path blockage. Design details of the storage area ventilation system are provided in Section 4.3.1. A scenario with blockage of half of the vent flow area as defined in NUREG 1567 was not considered credible as an off-normal event with its associated frequency. The off-normal event was defined as 25 percent blockage with 50 percent blockage considered infrequent enough to be defined as an accident condition. Calculations have been performed for scenarios with 50 percent blockage, which bound the lesser off-normal events. Vent blockage of 50 percent is considered an accident event and is discussed in Section 8.2.4.1 as part of the adiabatic heat-up evaluation.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

Foreign materials partially blocking the inlet and outlet vents or the annular tube vents are easily observed and manually removed. Blockage of exterior vents would be corrected from outside of the Storage Area portion of the facility. No significant dose is anticipated. The annular vents are even more readily available for visual observation; obstruction removal and normal housekeeping to allow for unobstructed CHM operation will limit blockage to planned maintenance activities. The vents are routinely accessible and the facility shielding is unaffected. For blockage resulting from personnel error, the cause will be evaluated and corrective actions implemented to prevent recurrence as appropriate. There would be no release of radioactive material and no radiological consequences.

8.1.4 Waste Handling Events

8.1.4.1 Breach of Waste Package in the Radioactive Waste Area

Postulated Cause of Event

The event considered is the breaching of a waste storage container within the Solid Waste Processing Area (SWPA). The cause of this event could be failure of the container handling equipment, impact with the forklift, the drop of an object onto a waste container, or operator error causing a drop or impact with sufficient force to breach the container.

Detection of Event

Breach of the container would require impact to, or dropping of, the container during handling or processing. The event would be readily observed and detected by the operator.

Analysis of Effects and Consequences

Solid waste is delivered from the FPA to the SWPA through the canister waste and process waste ports that connect the two areas. During operations in either the FPA or SWPA, a port plug is in place to isolate activities in either location. The FHM will be used to lower the radioactive waste into the SWPA. The FHM is designed to be single-failure-proof, but the lifting devices are not. Therefore, drop of the radioactive waste is postulated for this evaluation.

Radioactive waste dropped from the FPA would fall into the SWPA radiological enclosure. The waste would be isolated and would not be released to the environment or other ISF Facility areas. Operators are not in the SWPA while the transfer port is open, so personnel are not affected. Observation, ARMs, and routine monitoring of the SWPA would note any breach or any contamination above allowable limits before further processing.

The bounding scenario within the SWPA would be an impact with the forklift used to transport the waste container. The impact is assumed to have sufficient force to breach the package. Before this part of the operation, the container is handled in an enclosed area with radiation monitors, and any spread of contamination would be minimal. The relatively confined space to operate the fork lift and the limited speed of the vehicle will minimize the potential for damage to the stored waste containers and processing equipment. If an impact were to occur, the potential spread of contamination would be limited to the local area of impact, as the SWPA is designed to control the spread of contamination, with features such as isolation doors and controlled airflow. The consequences would be potential contamination rather than exposure and would not exceed the dose levels routinely anticipated during clean up of the enclosed SWPA work space.

A breach resulting from a drop of the container directly outside the SWPA when the waste containers are being loaded onto the transport vehicle for offsite transportation and disposal was considered, as this could result in contamination outside the ISF Facility. The drum containers to be used in the SWPA are fabricated from 16-gauge steel with rubber-gasketed, bolted-ring lids. A steel box will be used for a bulk container. The containers are required to meet U.S. Department of Transportation performance-based standards. The dropping of the container during loading is bounded by these performance-based requirements, and therefore will not result in a radioactive release.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

If a waste container is breached, the container would be returned to the SWPA for repackaging. The processing area is a controlled area. The facility radiological control procedures will be used to limit the spread of contamination and perform cleanup. The circumstances of the event would be reviewed according to the general administrative controls. The cause and any additional corrective actions would be identified and implemented to preclude further occurrences. Any contamination would be cleaned up following procedures and controls and if necessary, the waste container would be replaced. Decontamination procedures would be followed and contamination and ALARA controls specific to the event would be implemented. No radiological consequences outside the ISF Facility are anticipated.

8.1.4.2 High Dose Rate to Radioactive Waste Area

Postulated Cause of Event

The event considered is the transfer of a high dose rate object into the SWPA. As a worst-case scenario, a loaded fuel canister could inadvertently be moved from the FPA into the SWPA. This is unlikely as it would require multiple failures of operational, engineering, and administrative controls and procedures. A more likely scenario would be a high dose rate object attached to or included in a waste container that is moved to the SWPA. Also, a high dose rate object could be dropped from the FPA through an open transfer port into the SWPA. Any of the postulated events would be the result of multiple operator errors. As the transfer port is closed during FPA fuel packaging operations, failure of equipment or SNF components is not a credible cause of the event.

Detection of Event

Because of the higher radiation level, a high dose rate object in the SWPA would be detected by the ARMs as soon as the object started into the waste enclosure. If the port was opened inadvertently, the waste operator would note the plug removal and evacuate the area. If a fuel canister or object other than a standard waste container were transferred or dropped it would be observable by the FPA operator as it moved through the transfer port into the SWPA. If the radiation dose rate was above allowable limits, the object would be detected by the routine monitoring performed before waste processing.

Analysis of Effects and Consequences

The consequence of moving a loaded fuel container into the SWPA is significantly more severe than any other scenario, and represents the bounding condition. If a loaded fuel container was transferred into the SWPA and contamination was associated with the transferred container, the potential spread of contamination would be limited to the SWPA. The SWPA is designed to isolate any radioactive material on the components or equipment being processed as waste. There would be a significant increase in the radiological dose rate as the fuel moved through the port into the SWPA. Fixed radiation alarms in the SWPA would immediately alert facility personnel to the increase. No personnel would be in the waste processing area during this postulated event, as operators are not allowed to be in the SWPA when any waste transfer port is opened. If a port plug were inadvertently removed in preparation for a transfer, personnel would immediately exit the area. In the event that the personnel did not leave or entered the area during the event, the radiation monitor would provide a redundant back-up alarm alerting personnel in the waste area to cease operations and leave. However, the inadvertent lifting of a waste port plug would result in a significant impact to the HVAC system in comparison to the lifting of a transfer port with its inflatable seal. There would be a change in the differential pressure and the supply dampers would close to maintain operating pressures. The changes would alert the FPA operator to the event before the lifting device was changed and the fuel was moved.

Fuel packaging in the FPA is controlled by procedures to ensure that the correct process steps are followed. Movement of the fuel by the FHM is controlled by pre selected logic paths, using specific lifting devices, and no fuel processing is performed when the waste ports are open. Fuel in the FPA is required to be secured in designated storage locations before opening the waste ports.

Waste containers are surveyed before transfer to the waste enclosure to ensure acceptable dose rates inside of the container. Because of the controls and procedures required to move fuel within the FPA, the inadvertent lowering of a high dose rate object into the waste area by any means other than in a waste container is not considered a credible event. If a high dose object was inadvertently included in the waste containers, it would be detected by the ARMs prior to full insertion into the waste area. As operators are not allowed in the SWPA during transfer of waste into the SWPA radiological enclosure and the incoming waste would be monitored prior to processing of the waste, there would be no personnel exposure above acceptable anticipated limits. If the dose was too low to be detectable by fixed instrumentation, it would be noted by routine monitoring performed per ISF procedures to ensure acceptable levels for processing or in preparation for transferring the waste from the ISF Facility. A shield wall is provided between the operator station and the entry port to provide operator shielding if required after waste is received in the SWPA. The operator would follow pre-approved procedures to determine the proper course of action. The exposure to the operator would not exceed acceptable levels because routine monitoring would detect the unacceptable dose rates and procedures would not allow further processing of the waste until the condition was corrected.

The administrative procedures and controls used for the operation of the FPA determine the sequence and limit the activities that can be performed when the waste transfer port plug is removed. The SWPA operations are performed and the ports are opened only when no fuel packaging operations are in process. This eliminates the potential for dropping objects during the packaging activities. Additionally, each location and movement of fuel containers is procedurally controlled to minimize canister mishandling.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

Recovery procedures would be prepared specific to the event. These would be used to move the high dose rate object from the SWPA back into the FPA and to perform any required cleanup. Dose rate above allowable limits would require that the container or object be returned to the remote FPA for the required corrective action. Circumstances of the event would be reviewed and the cause and any necessary corrective actions would be identified and implemented. There would be no release of radioactive material and no significant radiological consequences.

8.1.5 Other Events

8.1.5.1 Ventilation System Failures

Postulated Cause of Event

The event considered here is the failure of the ISF Facility ventilation system. Failure could result from a number of scenarios such as loss of power to the facility or system, component breakdown, control system malfunction, or operator error. The FPA is the only portion of the system with the potential for significant radiological release. A number of ventilation faults can be postulated, including:

- full system shutdown (loss of normal and standby power)
- inlet fan failure
- exhaust fan failure
- filter blocked
- damper closed
- filter breached
- insufficient airflow

Loss of power can occur because of supply system failure or natural phenomena impact. The inlet and exhaust fans can fail because of loss of power, control system failure, driver motor failure, or catastrophic equipment failure. Blockage of the HEPA filters could be the result of excessive particulate deposition on the filter media or debris on the filter inlet. The dampers can fail closed due to component or control system failure or because of operator error. HEPA filters could be breached by seal failure. Loss of airflow to the FPA with the enclosure lighting illuminated could result from the an HVAC equipment failure or an operator error.

Detection of Event

Loss of power is readily observable. Indication on the control panel shows which fans are running and at what parameters. Fan failures not detected by observation of the indication lamps may be detected by the change or loss of differential pressure across the filter, which is routinely monitored, or by change in the sound or noise level of the system. Failed or closed dampers will be indicated by a change in the differential pressure with a corresponding adjustment in the fan operation or by observation of the damper positions. A breached filter will be detected if there is a release of airborne particulate (which will register on the stack monitor) or if a loss of differential pressure across the filter is observed. Routine differential pressure measurement across the filters will reveal a blocked filter. Failure to shut off the enclosure lights with the HVAC providing no airflow will be visually observable to the operator and will result in an increase in the FPA temperature.

Analysis of Effects and Consequences

The ISF Facility including the HVAC system is designed to ensure that the spent fuel can be handled safely and without significant contamination of areas within the facility. The ISF Facility including the ventilation systems have been designed and fabricated to address ALARA controls and practices as described in Section 4.3.1 and Section 7.1. Because of the design, a loss of the ventilation system under normal or off-normal operating conditions does not create a serious hazard. The HVAC system is designed to fail safe and to ensure that the FPA pressure remains either negative or neutral. The FPA is designed to provide confinement of the radioactive materials. Calculations indicate that even with a slightly positive pressure, there is no significant release of radioactive material and no adverse radiological consequences would result.

The ISF Facility electrical system and HVAC system are designed to safely shut down in a seismic event; however, one supply fan and one exhaust fan are connected to the standby power system and could provide up to 24 hours of continuous operation before the generators require additional fuel. These fans could continue to operate during a power outage to maintain the differential room pressures. The fans could also operate as necessary during any FPA recovery task in preparation for a longer term shutdown.

The ventilation system includes both supply and exhaust HEPA filters for the FPA. Routine housekeeping within the FPA will minimize the particulate and debris load on the exhaust filters. The pressure drop across the filters is routinely measured to assess particulate buildup on the filters in order to determine the need, timing, and frequency of filter replacement.

The inadvertent closing or failure of dampers would impact the differential pressure in the FPA. However, the HVAC control system is designed to react to changes in equipment and parameters to ensure that the pressure remains within the operational range. Manual balancing dampers for the FPA remain in the as-is position when the fans are shut down for maintenance. Tornado dampers on the supply duct and the exhaust duct close to protect the filters from the negative pressure created by the tornado and to maintain the confinement barrier. An operator could fail to re-open a damper. Attempting to operate the fans without opening the dampers will trip the fan as a result of deadheading. Fire dampers in ducts penetrating the FPA use an electrical-thermal link to automatically close the damper either by a signal or by sensing a set temperature.

Failure of a HEPA filter seal is unlikely, as the filters are subject to extensive test and inspections by the vendor to meet the required specifications and are checked for proper operation at the time of installation. However, in the event of a seal failure because of component failure or improper installation, the system has built-in checks and redundancies to ensure that there would be no significant release of radioactive materials. A newly installed filter has an observable pressure drop if properly sealed. Failure during installation or operation would be observable because of the absence or loss of that pressure differential. In the event that the failure was not detected, the exhaust system includes filters inside the FPA and additional redundant exhaust filters outside of the FPA. The exhaust stack monitor would provide a final indicator if all elements of the system were somehow breached.

Insufficient airflow does not affect the ability of the ISF components and structures to maintain confinement. As noted, the HVAC system is designed to ensure that the FPA pressure remains neutral on shutdown. Complete loss of the ventilation system without a corresponding shutdown of the enclosure lighting will result in an increased enclosure temperature. The allowable temperature limit is determined by the materials used for fabrication of process equipment and structural components, rather than by the SNF. Temperature controls will be set to protect the equipment and structures providing a limit well below the maximum allowable clad temperature. The maximum heat-up scenario would involve expansion of the enclosure atmosphere with the potential for a slight positive pressure. Release of radioactive material would be negligible due to the FPA design. Inlet and outlet ducts are equipped with HEPA filters and low leak rates are specified for windows, tornado dampers, and other confinement penetration seals. If overpressure were to occur it could result in some contamination of the adjacent areas. Radioactive material released through the enclosure penetrations would be contained within the ISF Facility and would require decontamination of the affected areas.

Calculations indicate that the maximum in-process fuel temperature under normal or off-normal conditions occurs with the fuel in the Fuel Operations and Monitoring Station of the FPA. The fuel can reach a maximum temperature of 305°F and the non-structural concrete shielding can reach 172°F. The maximum temperatures of the fuel and facility components are below the 400°F and 200°F respective maximum allowable limits (Table 4.2-53). They result in no adverse effects to the fuel or the facility.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

In the event of ventilation system fan failure, the in-process SNF will be left in place or moved to a predetermined configuration as appropriate, operations will be suspended, and the ventilation system repaired. When a blocked filter or breached filter is discovered this will also be addressed using standard procedures for the specific filter location. If a damper is found to be closed, it will be re-opened. The circumstances of any ventilation failure will be reviewed and appropriate corrective actions implemented. Decontamination would be performed using approved procedures and ALARA practices. If monitoring or observation of the FPA temperatures indicated a trend toward the maximum allowable limits because of the process lighting, any non-emergency lights would be turned off pending repair of the HVAC system. Release of radioactive material resulting from loss of negative pressure would consist of minor contamination of areas adjacent to the FPA, and would be contained within the facility. The contamination would be cleaned up using standard decontamination procedures. No significant release of radioactive material outside of the facility and no adverse offsite radiological consequences are anticipated to result from failure of the HVAC system or any individual HVAC system component.

8.1.5.2 Loss of External Power Supply for a Limited Duration

Postulated Cause of Event

The event under consideration is a loss of the source of external power to the ISF Facility for a period of up to 24 hours. The cause of the event could be a number of external accidents, equipment breakdowns or malfunctions, or natural phenomena that result in a failure of the power utility network outside of the ISF Facility.

Detection of Event

This event would likely be detected by observation. The loss of function in powered equipment including lighting, services, or process operation would be readily recognized. Battery powered emergency lighting would be automatically illuminated along with activation or continued operation of specific systems on uninterruptible power supply (UPS) or standby power.

Analysis of Effects and Consequences

ISF Facility operations are designed to shut down in a safe mode upon loss of power. Although there are functions powered by UPS or standby power systems, these are operational or maintenance functions and are not required for safe shutdown of the facility or facility operations. Normal power functions are not required to enter and maintain a safe shutdown mode. The facility UPS and standby power systems are not emergency power and can be allowed to fail. Systems or components that require emergency power have dedicated local UPS.

The major consequence of loss of external power would be the loss of the HVAC system, with a corresponding loss of the negative pressure differential in the FPA and the continued generation of heat from the fuel or environment with no airflow to provide in-process heat transfer. The loss of negative pressure results in a neutral pressure in the FPA with negligible airflow into or out of the confinement area. Both the inlet and exhaust FPA ventilation ducts are provided with HEPA filtration and confinement barriers such as penetration seals and dampers remain intact. The loss of differential pressure is discussed in Section 8.1.5.1, *Ventilation System Failures*.

Loss of the HVAC system for any reason including loss of power has been evaluated and maximum and minimum facility area temperatures have been calculated based on the extreme off-normal ambient temperatures. Conservative limiting temperatures for each area are provided in Chapter 4, Table 4.3-2. Minimum temperatures may require suspension of operations using manual backup features, but will not damage the fuel or the facility structures. It may be necessary to drain portions of the water systems if ISF area temperatures drop below freezing.

The in-process fuel temperatures for the limited duration outage are bound by the calculations of the maximum steady-state off-normal fuel temperatures analyzed at each in-process area. These calculations indicated that SNF would not approach the maximum allowable fuel or facility temperatures at any in-process location under maximum off-normal conditions as discussed in Sections 8.1.3.4, 8.1.5.1, and 8.1.5.3. The stored SNF in the storage tubes is cooled by natural convection; electrical power is not required to cool stored fuel. As stated previously, short-term minimum temperatures are not a concern for handling or storage of the SNF.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

Recovery and/or Corrective Actions

There is no requirement to complete any operations before restoration of power under the limited power loss scenario. The ISF Facility is designed to shut systems down in a safe manner and standby power is available for the maximum outage period to operate the HVAC. The generator has sufficient fuel to operate for a minimum of 24 hours before refueling. The operation of the generator can be extended by providing additional fuel; however, safe shutdown of the facility does not require operation of the generator. The temperatures do not exceed allowable limits with conservative assumptions and no intervention. Depending on the anticipated length of the limited duration outage, in-process SNF may be moved to a different location. To accomplish this, the FHM hoist can be operated manually or on standby power provided by diesel generators. Manual back-up capability is provided on the FHM, CHM, and the receipt crane. While it may be desirable, it is not necessary to move SNF or equipment to achieve a safe facility status. There would be no release of radioactive material, and no adverse radiological consequences would result from the limited duration loss of power.

8.1.5.3 Off-Normal Ambient Temperatures

Postulated Cause of Event

The event considered involves severe sustained high temperature or low temperature scenarios. The cause of the event is extreme weather phenomena or operating conditions resulting in the upper or lower range of parameters for any off-normal operation. As a basis for analysis, it is assumed that the loaded shipping cask, the in-process fuel containers, and the stored canisters are subjected to the maximum high and minimum low off-normal ambient temperatures for an extended period. To provide a conservative evaluation, the maximum temperatures are considered to remain constant, i.e., no credit is taken for normal diurnal temperature variations.

Detection of Event

The extreme temperatures of these events would be readily detected by the observation of operations personnel and confirmed by ambient temperature monitoring.

Analysis of Effects and Consequences

Sustained temperature extremes of the magnitude analyzed are not anticipated, as even extended periods of high or low temperatures have diurnal fluctuations. The ISF Facility is designed to withstand the extremes and the HVAC system is designed to provide control of the facility temperatures during periods of maximum and minimum off-normal process temperatures and normal ambient weather extremes. The HVAC maintains temperatures, in areas other than the Cask Receipt Area or the Storage Area, within the normal ranges under these conditions. The Cask Receipt Area and Storage Area have exhaust fans and heaters that are provided for personnel comfort rather than climate control. The HVAC system and the design temperatures are discussed in Section 4.2.3.3.6. The HVAC system is not designed to function during extreme off-normal ambient temperatures. The off-normal ambient maximum and minimum temperatures considered are based on the location of the ISF Facility and the weather and natural phenomena history of the site, and on the fuel types and process operations.

High or low temperatures in areas other than the Cask Receipt Area or the Storage Area would be mitigated by operation of the HVAC system to maintain normal facility temperatures for the extremes of normal ambient conditions. The HVAC system would continue to operate during periods of high off-normal ambient temperatures, but may not be capable of maintaining the normal range of facility temperatures. If facility areas exceed maximum or minimum allowable area operating temperatures, operations would be suspended. The ISF procedures would suspend operations for extreme temperatures regardless of the initiating event. The range of off-normal temperatures within the facility has been calculated for each area of the ISF Facility and is provided in Chapter 4, Table 4.2-50. Within the ISF, calculations were performed to determine the maximum steady-state temperatures, under the maximum off-normal conditions for the SNF and associated structures in the following configurations:

- DOE canisters in the fuel operations and monitoring station
- decanning station for Peach Bottom fuel
- fuel bucket operations station for TRIGA fuel
- ISF baskets in the fuel loading stations

- ISF canisters in the ISF Transfer Cask
- ISF canisters at the CCA
- ISF canisters in the CHM
- ISF canisters in the Storage Area vault

Maximum temperatures of the fuel and surrounding structures were calculated for sustained off-normal facility temperatures with maximum anticipated decay heat sources. The calculations assumed that the fuel has reached steady-state conditions relative to the ambient temperatures. The maximum anticipated total heat source for each fuel type and for ISF canisters in the storage vault containing generic heat sources of 40W and 120W was used in the analyses. No specific fuel type was associated with the generic configurations.

The maximum fuel temperature for any fuel type was found to be in the FPA fuel operations and monitoring station and was calculated to be 305°F. The temperature of the non-structural concrete shielding was determined to be 172°F. These temperatures were for TRIGA fuel and Peach Bottom Fuel concrete at the operation and monitoring station and subjected to a sustained off-normal ambient temperature of 165°F. The maximum temperatures of the fuel and facility components are below the 400°F and 200°F respective maximum allowable limits (see Chapter 4, Table 4.2-53). They result in no adverse effects to the fuel or to the facility. The allowable temperature for structural materials is provided in Chapter 4, Table 4.2-53.

Extreme low temperatures have no impact, as the ISF Facility design addresses the full range of normal and off-normal temperatures anticipated over the life of the facility. Design criteria and details of the systems used to maintain the conditions are discussed in Section 4.2.3.3.6. Restrictions on the facility, equipment, and SNF containers during ISF operations are limited to specific process minimum requirements. These include a minimum temperature required for moisture removal from the ISF canisters, and a minimum temperature established to meet code requirements for some lifting equipment structural materials. In the case of canister moisture content, the temperature and vacuum of the CCA dry and helium fill operation are controlled by procedures to ensure that the necessary vacuum drying parameters are met and the moisture is removed. Unacceptable parameters would require the process to be repeated or suspended until acceptable conditions are achieved. For the requirements imposed on lifting equipment, operations are curtailed if room temperatures are below 32°F. The thermal characteristics of the Peach Bottom Transfer Cask are provided in Appendix A.

Recovery and/or Corrective Actions

The calculated in-process fuel temperatures resulting from extreme ambient conditions are well below the maximum allowable fuel temperatures for each fuel type. The facility structures are designed to operate under the full range of off-normal temperatures and the storage vault is designed to operate safely under the maximum off-normal temperatures with no HVAC input required. Normal operations of transfer equipment will be curtailed if room temperatures drop below 32°F.

Operations within the other areas of the ISF Facility will be curtailed or limited if temperatures exceed or drop below the normal temperatures shown in Chapter 4, Table 4.2-50. The minimum operational temperatures are controlled by procedures.

As there would be no damage to SNF containers or SNF, there would be no release of radioactive material and no increase in anticipated exposure levels associated with these conditions. Recovery would involve resumption or restart of the facility operations using standard ISF procedures.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

8.1.6 Radiological Impact from Off-Normal Operations

This section evaluates the ISF Facility's capability to operate safely within the range of anticipated operating variations, malfunctions of equipment, and operator error discussed for the off-normal events previously discussed. Table 8.1-1 provides the off-normal event evaluated, the associated estimated dose (person-mrem), the method or means for detecting the event, the cause of the event, the associated corrective actions, and the effects and consequences.

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8.2 ACCIDENTS

This section provides the results of analyses of Design Events III and IV from ANSI/ANS-57.9-1984 and of several beyond design basis accidents. In accordance with 10 CFR 72, analyses are provided for a range of hypothetical accidents (Ref. 8-10).

Reviews of the Safety Analysis Reports of other facility activities at the INTEC have determined that no credible explosion or fire associated with a co-located INTEC facility could occur that would pose a threat to the ISF Facility, which either exceeds a vehicular fire related to an ISF Facility service vehicle (Section 8.2.4.4), or exceeds the potential impacts of either wind loading or a tornado missile scenario (Section 8.2.5.4) (Ref. 8-11). Thus, the impacts of credible accidents involving fire or explosion at co-located INTEC facilities are bounded by the analysis of the design basis tornado and the combustion of fuel from an ISF Facility service vehicle.

In the following section, each accident condition is analyzed to demonstrate that the applicable requirements of 10 CFR 72.122 are met and that adequate safety margins exist for the ISF Facility design. Radiological calculations were performed to confirm that onsite and offsite dose rates are within acceptable limits, as needed. The results show that the ISF Facility provides an adequate margin of safety for the protection of the public, facility personnel, and the environment.

8.2.1 Transfer Cask Events

8.2.1.1 Vehicular Collision with Transporter

Collision of a vehicle with the Transfer Cask during transport from the ISF site boundary fence to the Cask Receipt Area is bounded by the transportation evaluation of the Peach Bottom cask in Appendix A. Impact of the transport with the ISF Facility structure is addressed in Section 8.2.4.3.

8.2.1.2 Transfer Cask Drop During Hoisting Operations

Cause of Accident

This accident is not considered credible because the Transfer Cask will be handled with single-failure-proof lifting arrangements. The cask receipt crane, interfacing lifting devices, and the Transfer Cask lifting trunnions have been designed and/or verified to comply with NUREG-0612*, Control of Heavy Loads at Nuclear Power Plants, Resolution of Generic Technical Activity A-36*.

Accident Analysis

The Transfer Cask is lifted within the Cask Receipt Area by a 155-ton hoist from a horizontal position on the transport trailer. After raising the Transfer Cask to a vertical position, the transport vehicle is removed and a transfer trolley is put into place for support of the Transfer Cask in the vertical position. The floor area, a concrete basemat, provides the receiving surface for a worst-case drop configuration. The highest elevation of the bottom of the Transfer Cask would be in a vertical configuration approximately 10 feet above the floor, with the bottom of the Transfer Cask parallel to the plane of the concrete floor.

No additional analysis was performed for this postulated cask drop since the lifting configuration ensures a drop is not credible. The design details and drop analysis for the Transfer Cask are described in Appendix A of this SAR.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change in the criticality, confinement, or retrievability of the SNF.

Radiological Consequences

This event is not considered credible due to ISF Facility design features. Therefore, there are no radiological releases or adverse radiological consequences.

8.2.1.3 Transfer Cask Tipover

Cause of Accident

This accident is not considered credible because there is no known causal factor that results in the Transfer Cask overturning. As shown in the evaluation of tornadoes, earthquakes, floods, and explosions, no known events at the ISF site would result in overturning of the Transfer Cask in the Cask Receipt Area.

Accident Analysis

The Transfer Cask is lifted from a horizontal position on the transport vehicle to a vertical position. The transport trailer is then removed and a cask trolley is positioned under the suspended Transfer Cask; the cask is then placed directly in the cask trolley.

The cask trolley is designed with a wide footprint, uplift restraints on the trolley rails, and the Transfer Cask is secured to the cask trolley to prevent overturning. In addition, an axle failure on the cask trolley will allow only a 1-inch drop of the trolley supported by the wheel. This is not sufficient to create a tipover concern as this scenario is part of the cask trolley design criteria. Therefore, this postulated event is not credible.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change in criticality, confinement, or retrievability of the SNF.

Radiological Consequences

This event is not considered credible due to ISF Facility design features. Therefore, there are no radiological releases or adverse radiological consequences.

8.2.1.4 Cask Trolley Collision Events

Cause of Accident

The cask trolley is used to move the Transfer Cask into the decontamination area, under the FPA port for fuel transfer, and to return the empty cask to the Cask Receipt Area for return. The cask trolley rides on rails; this limited movement path prevents any credible impacts into structural members or fixed location components. However, the inner and outer Transfer Tunnel doors and the canister trolley on the same track are potential impact sites during movement of the cask trolley.

Accident Analysis

Proximity sensors in the Transfer Tunnel provide positional information for control and operational interlock functions and initiation of speed controller functions (deceleration, etc.) to facilitate accurate positioning at each trolley stopping station. Overtravel of the trolley is prevented by an end-of-travel limit switch hardwired into the drive contactor control circuit. In addition, bumpers at each end minimize impact against the canister trolley, rail-mounted end stops, or inadvertently closed doors. The cask trolley is designed for impacts at a speed of up to 10 fpm without damage to the trolley or cask. The maximum operating speed for the cask trolley is 10 fpm. The cask trolley impact against the rail stops or canister trolley will be minimized by bumpers designed for an average rate of deceleration of 4.7 ft/sec^2 (0.15 g) in accordance with Crane Manufacturers Association of America (CMAA) 70 (Ref. 8-12). The resulting forces from this deceleration are bounded by seismic and other loads and are not bounding in the trolley design. In addition, the Transfer Cask is rigidly mounted in the trolley. The ability of the Transfer Cask to withstand this deceleration is discussed in Appendix A of this SAR.

Radiological Consequences

There are no radiological releases or adverse radiological consequences due to the integrity of the confinement barriers and shielding material.

8.2.2 Fuel Packaging Events

8.2.2.1 Drop of DOE Fuel Container During Handling

Cause of Accident

The accident considered here is dropping a DOE fuel container from the maximum height of the FHM into the Peach Bottom cask or onto the FPA floor. Single-failure-proof lifting devices handle the loaded DOE fuel containers as described in Chapter 4. Some of the DOE fuel containers have not been demonstrated to meet the single-failure-proof criteria of NUREG-0612 (Ref 8-6). A drop of these fuel containers is discussed in Section 8.2.2.1 of Appendix A to the SAR, *Safety Evaluation of the Transfer Cask*. For information on handling of individual fuel elements, refer to Section 8.1.2.4. A discussion of the ISF Facility design features and operations that minimize the probability of a drop scenario are presented below.

1. Operator Errors

   The lifting devices used in conjunction with the FHM for lifting DOE fuel containers will be used remotely by operators viewing the FHM operations through the shielded windows of the FPA. They are mechanical devices that require no electrical, hydraulic or pneumatic services and they have no remote latching or delatching capability. Latchings and delatchings will be performed mechanically by the operator using the PMS or MSM. The top hook eye of each lifting device will be fitted to the FHM hook. The FHM hook will have a safety latch actuated by the PMS or MSM that ensures that the lifting device stays secured to the hook. The operators are provided with visual indication that the lifting device is engaged and locked to the item being lifted. This approach ensures that there is no single action by which the operator could inadvertently release a load from the FHM during handling operations.

2. Mechanical Failure

The FHM crane, including the hoist design meets the requirements of NUREG-0554, *Single-Failure-Proof Cranes for Nuclear Power Plants*. These requirements are met by designing the FHM to meet the requirements of Crane Manufacturers Association of America (CMAA), Specification 70, and American Society of Mechanical Engineers (ASME) B30.2, as supplemented with additional requirements of NUREG-0612, *Control of Heavy Loads at Nuclear Power Plants*, NUREG-0554; and AWS D1.1 *Structural Welding Code* (in lieu of AWS D1.14 specified in CMAA-70).

Lifting devices used for handling fuel comply with ANSI/ANS N14.6-1993. For lifting devices with dual load paths, the load-bearing members of the lifting devices are designed to lift three times the weight without exceeding the minimum tensile yield, and five times the weight without exceeding the ultimate tensile strength of the materials. For lifting devices with a single load path, the load-bearing members of the lifting devices are designed to lift six times the weight without exceeding the minimum tensile yield and ten times the weight without exceeding the ultimate tensile strength of the materials. Certain lifting devices used to handle fuel in the FPA have been designed to handle fuel elements where a single failure proof load path, or dual load paths, are not possible. An example is a friction grip device used to handle Peach Bottom Core 2 fuels where the handling feature on the fuel element has been removed. These devices will not meet all requirements of ANSI N14.6, Section 4.3.5 (positive means of attachment to the fuel under load in all handling positions) and 7.1b (single failure proof design). The fuel handling operations in question will occur within the FPA confinement boundary, and the fuels will be packaged and stored in a manner consistent with NRC requirements for failed fuel. Under these conditions, dropping a fuel element will not result in unacceptable dose consequences during handling or storage. Therefore, these exceptions are considered acceptable.

The FHM will be proof loaded to the requirements of NUREG-0612 and CMAA 70. The lifting devices will be proof loaded to 300 percent of the maximum critical load in accordance with ANSI/ANS N14.6. The FHM maintenance criteria are provided in NUREG-0554; ANSI N14.6 provides for periodic testing of lifting devices; and ANSI/ASME B30.2 provides for maintenance and periodic testing and inspection.

Those DOE fuel containers that have not been demonstrated to meet the single-failure-proof design criteria are discussed in Section 8.2.2.1 of Appendix A of the SAR.

3. Electrical Failure

The FHM hoist uses two separate hoist motors, gear reducers, and hoist cables, to ensure redundant electrical systems are available to hold and move the load. The lifting devices are mechanically delatched using the PMS or MSM. An electrical failure can therefore not cause a decoupling of the lifting device.

4. Seismic Damage

   The lifting devices are mechanically delatched using the PMS or MSM. An electrical failure such as from activation of the facility seismic switch can therefore not cause a decoupling of the lifting device. The lateral loads on the lifting device in a seismic event will be small compared to normal operating loads.

5. Hoist System Failure

   The FHM hoist is a single-failure-proof system designed to the requirements of NUREG-0554, as described in Item 2 above. The hoist includes redundant hoist motors, gear reducers, and hoist cables. Thus, protection against a drop accident is inherent in the engineering design.

Accident Analysis

The consequences associated with the drop of a DOE fuel container during handling are discussed in Section 8.2.2.1 of Appendix A of the SAR.

8.2.2.2 Drop of ISF Basket During Handling

Cause of Accident

The accident considered here is dropping an ISF basket from the maximum height possible while suspended from the FHM hoist into the ISF canister or onto the FPA floor. The loaded ISF basket is handled by single-failure-proof lifting devices as described in Section 4.7. Therefore, no credible drop scenarios can be constructed for a basket suspended by the FHM. Additional discussion of why this drop scenario is not credible is presented below.

1. Operator Errors

   The lifting devices used in conjunction with the FHM for lifting baskets will be used remotely by operators viewing the FHM operations through the shielded windows of the FPA. They are mechanical devices that require no electrical, hydraulic or pneumatic services and they have no remote latching or delatching capability. All latchings and delatchings will be performed mechanically by the operator using the PMS or MSM. The top hook eye of each lifting device will be fitted to the FHM hook. The FHM hook will have a safety latch actuated by the PMS or MSM that assures the lifting device stays secured to the hook. The operators are provided with visual indication that the lifting device is engaged and locked to the item being lifted. This approach ensures there is no single action by which the operator could inadvertently release a load from the FHM during handling operations.

2. Mechanical Failure

   The FHM crane, including the hoist, is a single-failure-proof design that meets the requirements of NUREG-0554. These requirements are met by designing the FHM to meet the requirements of CMAA 70, and ASME B30.2, as supplemented with the additional requirements imposed by NUREG-0612, NUREG-0554 and AWS D1.1.

Lifting devices used for handling the ISF basket comply with ANSI/ANS N14.6. For lifting devices with dual load paths, the load-bearing members of the lifting devices are designed to be lift three times the weight without exceeding the minimum tensile yield and five times the weight without exceeding the ultimate tensile strength of the materials. For lifting devices with a single load path, the load-bearing members of the lifting devices are designed to lift six times the weight without exceeding the minimum tensile yield and ten times the weight without exceeding the ultimate tensile strength of the materials.

The FHM hoist will be proof loaded to the requirements of NUREG-0612 and CMAA 70. The lifting devices will be proof loaded to 300 percent of the maximum critical load in accordance with ANSI/ANS N14.6. The FHM maintenance criteria are provided in NUREG-0554; ANSI N14.6 provides for periodic testing of lifting devices; and ANSI/ASME B30.2 provides for maintenance and periodic testing and inspection.

The basket structural attachment points to the lifting devices are discussed in Appendix A.

3. Electrical Failure

The FHM hoist uses two separate hoist motors, gear reducers, and hoist cables, to ensure redundant electrical systems are available to hold and move the load. The lifting devices are mechanically delatched using the PMS or MSM. An electrical failure can therefore not cause a decoupling of the lifting device.

4. Seismic Damage

The lifting devices are mechanically delatched using the PMS or MSM. An electrical failure can therefore not cause a decoupling of the lifting device. The lateral loads on the lifting device in a seismic event will be small compared to normal operating loads.

5. Hoist System Failure

The FHM hoist is a single-failure-proof system designed to the requirements of NUREG-0554, as described in Item 2 above. The hoist includes redundant hoist motors, gear reducers, and hoist cables. Thus, protection against a drop accident is inherent in the engineering design.

Accident Analysis

Based on the design features provided to ensure that the load is supported in accordance with NRC guidance, this hypothetical accident is not considered credible. The structural integrity of the ISF basket is maintained, thereby maintaining the integrity of the fuel. Therefore, there is no change in criticality conditions, confinement, or retrievability of the SNF.

Radiological Consequences

The structural integrity of the basket is maintained, thereby maintaining the integrity of the fuel. Therefore, there are no postulated radiological releases or adverse radiological consequences for this postulated event.

8.2.2.3 Canister Trolley Movement in Raised Position

Cause of Accident

The postulated accident involves motion of the canister trolley on the rails while the canister cask and filled canister are in an elevated position or in transit to an elevated position. The canister trolley performs three primary transfer functions: 1) moving a new ISF canister from the CCA storage location to the FPA port, 2) returning the filled canister to the CCA port for canister closure, and 3) moving the canister to the Storage Area port for retrieval by the CHM. At each port location (CCA, FPA, and storage area ports), the canister and canister cask must be raised into and lowered from the port opening using the canister trolley jacking function. Further descriptions of the canister trolley jacking function and operational sequences are found in Sections 5.1.1.2.9-11 and 4.7.3.2.3. The postulated accident is caused by movement of the canister trolley on the rails while the canister and canister cask are in the elevated position at a port opening or during the raising or lowering of the canister and canister cask into the CCA port, storage area port, or FPA port. Controls for the canister trolley movement are manually actuated from the CCA and monitored by video camera input and sensor inputs at the control panel. Operator error or electrical faults are the postulated methods for attempting to move a canister trolley with the canister and canister cask in the raised position.

Accident Analysis

Proximity sensors in the Transfer Tunnel provide positional information used for indication, control, and operational interlock functions and initiation of speed controller functions (deceleration, etc.) to facilitate accurate positioning at each trolley stopping station. When the canister trolley is positioned under the appropriate port, an ITS locking pin will be used to seismically restrain the trolley during fuel transfer activities. An ITS interlock will prevent release of the locking pins when the jacking system is in any position other than fully lowered. As a result of physical restraint of the canister trolley by the locking pin and the locking pin/jacking system interlock, an inappropriate operator action or single electrical fault cannot cause movement of the canister trolley with the canister cask in the raised position. This postulated accident is considered a non-credible event because it is protected by these ITS features. Therefore the structural integrity of the canister cask and canister are maintained, thereby maintaining the integrity of the SNF. There is no change in criticality conditions, confinement, or retrievability of the SNF.

Radiological Consequences

There are no radiological releases or adverse radiological consequences due to the integrity of the confinement barriers and shielding material.

8.2.3 Fuel Storage Accidents

8.2.3.1 ISF Canister Drop

Cause of Accident

The accident considered here is dropping a canister from the maximum possible hoist elevation of the CHM hoist into an open storage tube in the Storage Area. The loaded canister is handled by single-failure-proof lifting devices. Therefore, there are no credible drop scenarios for a canister suspended in the CHM. Additional discussion of why this drop case is not credible is presented below.

1. Operator Errors

The CHM hoist and canister grapple are both single-failure-proof lifting devices. It is possible for an operator to attempt to command the CHM to disengage the canister grapple while a canister is suspended. This is prevented by CHM mechanical and electrical interlocks. Positive mechanical interlocking is provided to ensure the grapple cannot disengage the canister unless the canister's weight is supported. An electrical interlock that uses the canister hoist load cell to detect the presence of a canister prevents the grapple from being opened while a canister is suspended. Electrical and control devices associated with the grapple are interlocked with the canister hoist controls; therefore, in a loaded condition the hoist cannot be operated unless the grapple jaws are locked in place and the appropriate weight detected.

A canister that is fouling against the side of the storage tube or contacting the charge face would reduce the load sensed by the hoist load cell, potentially allowing inadvertent release of the canister grapple. This is prevented by grapple control interlocks that prevent the grapple from operating unless the CHM is correctly positioned and locked, the turret properly aligned and locked in place, and the grapple in a recognized seating zone. This is also prevented by hoist control interlocks that detect a below-minimum-weight condition (indicating slack rope or a snag) and above maximum weight condition (potentially a snag). This approach ensures there are no means by which the operator could inadvertently release a load from the CHM during handling operations.

2. Mechanical Failure

The CHM, including the hoist, is a single-failure-proof design that meets the requirements of NUREG-0554. These requirements are met by designing the CHM to meet the requirements of CMAA 70, and ASME B30.2, as supplemented with the additional requirements imposed by NUREG-0612, NUREG-0554 and AWS D1.1.

The CHM canister grapple complies with ANSI/ANS N14.6. The canister grapple meets the requirements of a critical load handling device. For critical load lifting devices with a single load path, the load-bearing members of the lifting devices are designed to lift six times the weight without exceeding the minimum tensile yield and ten times the weight without exceeding the ultimate tensile strength of the materials. The canister hoist load cells will provide the feedback for grappled weight indication and are interlocked into the control system to ensure that the hoist and grapple are not overloaded.

The CHM will be tested to the requirements of NUREG-0612 and CMAA 70. The CHM maintenance criteria are provided in NUREG-0554, and ANSI/ASME B30.2 provides for maintenance and periodic testing and inspection.

3. Electrical Failure

Failure of the electrical system, including electrical interlocks, cannot cause a drop accident. Once loaded, the canister grapple cannot mechanically uncouple until the weight of the canister is removed.

4. Seismic Damage

   The canister grapple cannot release when the canister weight is sensed by the hoist load cells and hence while the load is being carried. The lateral loads on the canister grapple are small compared to normal operating loads.

5. Hoist System Failure

   The hoist support system is double suspension designed to the requirements of NUREG-0554 as described in Item 2 above. The canister grapple meets the requirements of ANSI/ANS N14.6. Thus, protection against a drop accident is inherent in the engineering design.

Accident Analysis

The CHM is used to position the canister over a pre-selected storage location and then lower it into the storage tube. Based on the design features provided to ensure that the load is supported in accordance with NRC guidance, this hypothetical accident is not considered credible. Therefore, there is no change in criticality conditions, confinement, or retrievability of the fuel. However, as described in Section 4.2.3.3.1, this drop case has been evaluated as the worst-case non-mechanistic drop. The resulting stresses, reported in Table 4.2-11, are within Service Level D allowables.

Radiological Consequences

The structural integrity of the canister is maintained, thereby maintaining the integrity of the confinement boundary. Therefore, there are no postulated radiological releases or adverse radiological consequences directly resulting from the drop accident.

8.2.3.2 Transverse Movement of the CHM with an ISF Canister Partially Inserted

Cause of Accident

This postulated accident occurs when the CHM moves relative to 1) the storage area port when the canister is being moved between the canister trolley cask and the CHM; or 2) the storage tube opening when the canister is being moved between the CHM and the storage tube. This relative motion can be caused by inadvertent movement of the CHM bridge or trolley, rotation of the turret assembly, or lateral acceleration of the turret base produced by a seismic event. Motion of the CHM relative to the storage area port and storage tube is prevented by ITS seismic clamps/locking pins and ITS interlocks. The CHM seismic analysis demonstrates that when the CHM bridge, trolley, and turret are seismically restrained during canister hoist operations, the maximum lateral motion of the base of the CHM turret in a DE is insufficient to cause the postulated accident. Therefore, no credible scenario for this postulated accident can be constructed. Further discussion of why this postulated accident is not credible is described below.

1. Operator Error

   Manual operator action is required to initiate CHM motion, so operator error is postulated as a cause for this accident. During ISF canister transfer operations at both the load/unload port and the storage tube, the CHM bridge, trolley, and turret are seismically restrained by clamps or locking pins. For the CHM hoist to operate, several ITS interlocks must be met. The CHM bridge and trolley seismic clamps cannot be released and the bridge and trolley cannot be moved unless the CHM canister hoist is fully raised. The CHM turret locking pin cannot be disengaged and the turret cannot be rotated unless the canister hoist is fully raised. These interlocks are in place for all CHM canister hoist operations and prevent motion of the CHM or rotation of the turret when the canister is only partially raised or lowered.

2. Seismic Damage

   The span of the CHM system combined with the weight of the CHM turret assembly could potentially produce large lateral deflections at the nose of the CHM turret during a seismic event, potentially trapping the canister in the port or storage tube opening. ITS seismic clamps and locking pins restrain the CHM bridge, trolley, and turret assemblies from gross movements during ISF canister hoist operations. The CHM seismic analysis shows that when the CHM is seismically restrained, lateral motion of the CHM turret base produced by horizontal seismic acceleration in a DE is insufficient to cause this postulated accident.

Accident Analysis

Operator initiated attempts to move the CHM with a partially inserted ISF canister, either at the storage area load/unload port or storage tube, are prevented by ITS single-failure-proof interlocks. With the combination of procedural requirements for operator actions, seismic restraints and locking pins, and multiple interlocks to prevent inadvertent CHM movement while the ISF canister is partially raised or lowered, this event is considered not credible. Therefore, the structural integrity of the canister is maintained, thereby maintaining the integrity of the fuel. There is therefore no change to criticality conditions, confinement, or retrievability of the SNF.

Radiological Consequences

There are no radiological releases or adverse radiological consequences due to the integrity of the confinement barriers and shielding material.

8.2.4 Other Postulated Accidents

8.2.4.1 Adiabatic Heatup

Cause of Accident

This hypothetical accident would be caused by complete airflow blockage of the inlet and outlet vents and the inability of the facility to transfer any of the heat from the stored SNF to the surrounding environment. The analysis assumes that air flow through the facility ceases and no heat is transferred from the facility to the environment. Under normal and off-normal operating conditions, a continuous stream of air flows through sets of wire-mesh-screen covered inlet vents, around the storage tubes, and up through annular gaps in the charge face, then exits through fixed louvers mounted in the upper portion of the Storage Area. The airflow required for heat transfer in the Storage Area circulates by natural convection. The evaluation assumes that components of the airflow system cease to function. This non-mechanistic hypothetical analysis provides the most conservative thermal transient response of the vault considering only the SNF decay heat and the material heat capacity of the vault components. The analysis also analyzes an accident blockage of 50 percent of the ventilation system.

Accident Analysis

Adiabatic Heat Up

The analysis of this event uses a steady-state condition with the ambient temperature equal to 98°F and airflow in the annulus (between the storage tubes and up through the charge face) as the initial condition. The analysis is then changed to a transient condition with sudden removal of airflow in the annulus (simulating a full blockage condition with no internal air heat removed by convection and an adiabatic heat up of the storage tubes). A calculation was performed to compute the rate of temperature rise of the storage tube, its contents, and the charge face structure in the absence of any heat loss from the system.

The maximum rate of temperature rise for the storage tube, canister, and fuel is calculated to be 0.35°F per hour. Of these components, the concrete charge face, with a limiting normal maximum temperature of 150°F (Chapter 4, Table 4.2-53), reaches its limiting normal temperature first. Assuming an initial temperature equal to the normal operational maximum of the vault storage tube of 120°F , the concrete limiting temperature is reached approximately 3.5 days after air flow is assumed to be blocked. The off-normal maximum concrete temperature of 200°F is reached approximately 9.5 days after blockage. Over 24 days would be required before the concrete temperature reached the short term concrete temperature limit of 350°F allowed by ACI-349 (Ref. 8-41). Use of the storage tube temperature is conservative, as the vault concrete temperature would be lower than the tube temperature, requiring additional time to reach the limiting concrete temperature. Periodic surveillance is required by ISF procedures with a minimum frequency specified in Technical Specification 3.2.2. This surveillance will provide sufficient safety margin to preclude overheating accident events during SNF storage.

50-Percent Vent Blockage

Using the bounding TRIGA fuel, the analysis of a blockage-accident scenario with 50-percent blockage of the vent path indicates that a loaded canister in the Storage Area will reach a maximum basket fuel tube temperature of 138°F and the vault storage tube will reach a maximum of 123°F. The maximum temperatures of the fuel and facility components are below the 400°F and 200°F respective maximum allowable limits (Chapter 4, Table 4.2-53). Vent blockage is unlikely due the vent design and location. The inlets are each large openings, with half on the north wall and half on the south. They are more than 20 feet above outside ground level. Because screens are provided for the inlet vents, blocking material will be primarily on the outside and will be easily removed in a low exposure environment. There are no credible sources of blockage around storage tubes behind the air inlet screens, as the lower level is unoccupied. Annular vents are located on the charge face floor and discharge into the upper Storage Area. The floors are kept free of debris to enable operation of the CHM. Blockage by foreign material or debris would be unusual and would be readily observed. Also, the annular vents are easily accessible for removal of any foreign material. Outlet vents are large fixed louvers in the upper portion of the storage building, with a clear viewing path from inside or outside of the facility. They are also easily accessed for removal of obstructions. Additional details of the ventilation system are provided in Section 8.1.3.5.

Radiological Consequences

Although the adiabatic heat-up is a hypothetical event, 9.5 days would be ample time to correct the cause of the ventilation blockage or lack of heat transfer. Should any of the inlet or outlet vents be found blocked, foreign material causing the obstruction would be immediately removed. Even a 50 percent vent blockage non-adiabatic scenario is not considered to be credible. However, based on the surveillance requirements, the blockage would be noted and removed, eliminating any extended period potential. The Storage Area's ability to maintain adequate heat transfer (and therefore, geometry, confinement, and shielding) of the stored fuel would not be impaired. There would be no radiological releases and no radiological consequences from this event.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

8.2.4.2 Loss of Shielding

Cause of Accident

Natural phenomena, equipment failures, or personnel errors may cause degradation or loss of shielding. The causes, methods for detecting, and corrective actions for loss of shielding due to earthquake, fire and explosion, and vehicular impact are discussed in the other parts of this section where loss of shielding is involved or results from the postulated accident. Loss of shielding can also occur due to a tornado missile impact-induced penetration of concrete shielding or degradation of the charge face within the Storage Area. Potential tornado missile damage and loss of shielding are discussed in Section 8.2.5.4.

Personnel errors that may cause loss of shielding include failure to install a shield plug or to inadvertently remove a shield plug at the point in the processing where one is required. Postulated accidents related to shield plug installation errors are addressed in the paragraphs below.

Postulated Accident Scenarios

1. Failure to install shield plug in filled fuel basket at FPA canister port.

Postulated Cause of Event

This event is postulated to occur as a result of operator error. In this postulated accident, the operator fails to place the shield plug into the filled canister prior to releasing the canister trolley for transport to the CCA for canister closure. During normal processing, a filled fuel basket is placed into a new canister located in the canister trolley cask, which is positioned under the FPA canister port. The shield plug is normally placed into the canister by the FHM following placement of the full fuel basket into the canister.

Detection of Event

The presence of an open canister would be detected by the radiation area monitor in the Transfer Tunnel when the open canister is lowered from the FPA canister port. If the first monitor fails to detect elevated radiation levels, a second radiation area monitor located in the CCA would detect the open canister as the CCA port cover removal was initiated. The radiation monitors are tied into the IDCS, and trigger local and facility interlock alarms.

Analysis and Recovery

Fuel handling operations will be under administrative control and records of loading pattern/status will be routinely updated. No personnel are present in the Transfer Tunnel during movement of the canister trolley, therefore there is no risk of personnel exposure due to elevated radiation levels caused by the missing shield plug. The CCA cask port is shielded to insure that personnel who may be in the CCA during trolley movement in the Transfer Tunnel are not at risk of exposure. If the radiation area monitor in the Transfer Tunnel fails to detect the open canister, a second radiation monitor in the CCA will detect the open canister as the canister port is being raised, and it would be immediately replaced. An open canister detected in the Transfer Tunnel would be returned to the FPA for installation of the shield plug. This postulated accident would result in a delay in operations and locally elevated radiation levels.

2. Failure to install storage tube shield plug in storage tube.

Cause of Accident

A postulated loss of shielding can occur if the storage tube shield plug is not installed into the storage tube following placement of a sealed canister into the Storage Tube. This can be caused by operator error or by failure of the CHM to release the tube plug.

Detection of Event

Absence of a tube plug would be noted by the operator's observation of control panel indicators which report tube plug hoist, grapple, and cask status.

Analysis and Recovery

Fuel handling operations will be under administrative control and records of loading pattern/status will be routinely updated. The CHM provides redundant interlocks to ensure there is no loss of shielding if the tube plug is not placed into the storage tube. Shielding between the CHM canister cask and the charge face at the storage tube opening is provided by a shield skirt, which is in place any time fuel handling operations are taking place at the load/unload port or storage tube. Interlocks insure that the operator cannot raise the shield skirt, release the seismic restraints, or move the bridge and trolley without the tube plug in place in the storage tube. These single-failure-proof interlocks operate by detecting the position of the tube plug hoist, which must be fully raised, and/or the presence (or absence) of a tube plug in the tube plug cask. Therefore, an operator error resulting in a loss of shielding at the storage tube opening is not credible.

In the event of a failure of the tube plug hoist, there is a hand wind capability to allow raising or lowering of the tube plug manually. The tube plug can be lowered into the storage tube manually, thereby shielding the canister, or it can be raised into the tube plug cask and the canister recovered into the shielded cask while repairs to the hoist are made.

3. Shield plug removed from loaded canister at CCA port

Cause of Event

In this postulated accident, the operator in the CCA removes a shield plug from a filled canister located in the canister trolley cask located at the open CCA port.

Detection of Event

The presence of an open canister would be detected by the radiation area monitor in the CCA. The radiation monitor is tied into the IDCS, and triggers local and facility interlock alarms.

Analysis of Effects and Recovery

Fuel handling operations will be under administrative control and records of loading pattern/status will be routinely updated. The canister shield plug is handled in the CCA with a lifting eye installed into a threaded hole located on the lifting feature used to lift the shield plug in the FPA. The shield plug cannot be lifted in the CCA using the same lifting feature used in the FPA. Prior to delivering a new canister and shield plug to the FPA, this lifting eye is removed and replaced with a grub screw. This prevents any inadvertent lifting of the shield plug once it returns to the FPA on a filled canister, as the necessary lifting feature is no longer available. Should the operator attempt to replace the grub screw with the lifting eye and lift the shield plug, removal of the shield plug from a filled canister would be detected by the radiation area monitor and trigger a local alarm.

For the three postulated shield plug scenarios that can result in loss of shielding, the structural integrity of the canister cask and canister are maintained, thereby maintaining the integrity of the SNF. The radiation area monitoring and associated alarms described above must remain operational during the credible accident scenarios described above. There is no change in criticality conditions or retrievability of the SNF.

Radiological Consequences

The radiological consequence of the credible losses of shielding described above may include localized elevated radiation fields, however, no significant shielding concerns are raised, nor are any increased exposure rates expected. In the credible scenarios, radiation monitoring and alarms insure that any elevated radiation fields are detected as described and recovery activities can be immediately initiated.

8.2.4.3 Building Structural Failure onto Structures, Systems, or Components

Cause of Accident

The accident involves the failure of the building structure with subsequent impact to other ISF Facility structures, systems, and components (SSC). Failure of the facility structure could result from external forces such as vehicle impact, extreme natural phenomena, or overstressing of lifting mechanisms. The events considered include both concrete and steel structures where the failure of the structure has the potential for impacting ITS SSCs. This includes structures in the Cask Receipt Area, Storage Area, and Transfer Area.

Accident Analysis

The structures required to protect ITS SSCs and ensure ITS functions, or required to support lifting of ITS SSCs such as SNF casks, canisters, fuel containers, and SNF are designed to withstand anticipated natural phenomena including seismic events, as described in Section 3.2 and in Section 4.7.3.3. In addition, the not important to safety (NITS) primary structural steel members of the Cask Receipt Area, the Transfer Area, and the Storage Area have been designed to the same criteria and load combinations as ITS structures. These structures will continue to function during and after a natural event.

The building structures that make up the load paths of facility ITS cranes are designed using regulatory guidance and codes that provide a significant margin of safety for the maximum anticipated loads. The ITS cranes are described in Section 4.7.1 and 4.7.3, and their components are designed to be single-failure-proof, or incorporate added design margins if a single-failure-proof device is not feasible. These design criteria ensure that loads do not drop or collide with structural members as a result of fixture breakage, slipping, or shifting. The devices are provided with limit switches, overload protection, and interlocks as described in Section 5.2.1.2 to protect against jams, overloads, and equipment failures. Overloading of the building structures by ITS cranes would require multiple failures of handling equipment protection features in conjunction with failure to observe operational procedures.

Although failure of the building structures is not considered credible due to natural phenomena or overstressing of lifting mechanisms, the Cask Receipt Area structure could be hit by the truck used for transporting the SNF casks. Procedures limit the use and speed of vehicles within the controlled area to minimize the potential for and consequences of vehicle impact. A cask drop could result from an impact to the structure with sufficient force to cause structure damage. The only scenario with a cask in the elevated position, and with the potential for sufficient vehicle speed (and therefore sufficient impact energy), would occur while loading the empty cask on the truck for return. As there would be no SNF involved, there would be no significant radiological consequences. A transporter impact event involving a loaded cask could only occur while the cask was on the truck and the truck was being moved into the facility. In this event cask drop would be minimized and the fuel container would be protected by the transportation cask. The scenario would be bounded by the transportation accidents as discussed in Appendix A. Once unloading of the cask begins, the truck moves in limited increments heading out of the receipt area.

Radiological Consequences

Failure of the primary ISF Facility structures is not considered to be credible; therefore, there are no postulated radiological releases or adverse consequences from this event.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

8.2.4.4 Fire and Explosion

Cause of Accident

For fire hazard evaluation purposes the ISF Facility is divided into three fire areas. Fire Area 1 consists of the areas where spent fuel is removed from the Transfer Cask, processed into the ISF canisters, and prepared for storage. Fire Area 2 consists of the areas where the spent fuel is passively stored. Fire Area 3 consists of the remaining portions of the ISF Facility, support structures, and the yard area. Non-combustible structural members were used throughout the ISF Facility. However, certain areas contain small to moderate quantities of flammable or combustible materials and a fire is postulated to occur within these areas. Each fire area has unique properties to minimize the potential for exposing ITS SSCs to a postulated fire.

The ISF Facility exclusion zone within the fenced boundary is cleared of vegetation and either paved (access roads) or surfaced with compacted gravel. The Transfer Area and switchyard area, which contain ITS SSCs, are a minimum of 100 feet from the outer edge of the perimeter fence. The significant sources of combustibles inside the perimeter fence would be: (1) diesel fuel in the tank(s) of the transport tractor, and tires on the tractor and trailer; (2) gasoline/diesel fuel in the tank(s) of the waste processing or delivery vehicles, and tires on the truck and/or trailer; (3) lube oil in the various hoist gear boxes and trolley drives; and (4) diesel generator double-walled fuel tank in the switchyard area, which would contain up to 1000 gallons of fuel, located over 20 feet northeast of the Transfer Area, and over 100 feet from the perimeter fence.

The ISF Facility does not contain any flammable gas storage tanks on site or other products that could cause an explosion. The INTEC facility buildings, storage yards, fuel storage tanks, and access roads nearest the ISF Facility have been evaluated for potential impacts to the ISF Facility due to fire and explosions. Because of the limited combustible quantities and the substantial distances to the ISF Facility, it has been determined that they pose no threat to the ISF Facility ITS SSCs (Ref. 8-13).

Accident Analysis

Each fire area has unique fire loading characteristics and fire protection capabilities to address the postulated fire hazards. These will be described for each fire area separately. The combustible materials within each fire area/fire zone were estimated and then converted to a value that represents an equivalent fire duration. The standard used for this conversion was 80,000 btu/hr-sq. ft. as equivalent to a 1-hour fire duration. This standard is used for comparison purposes only, as the type of combustible material within each area or zone was considered for local impacts on ITS SSCs. As described below, none of the ISF Facility enclosures where ITS equipment or structures are located exceeds an equivalent fire duration loading of greater than 1 hour.

Fire Area 1 – Fuel Handling Areas

Fire Area 1 is divided into five fire zones, these are the FPA, FHM Maintenance Area, CCA, North Transfer Tunnel, and Decontamination Area (South Transfer Tunnel). The purpose of this fire area boundary is to isolate ITS fuel handling and packaging activities from credible fires outside this area. The structural walls, floors, and ceiling surrounding this fire area are of reinforced concrete, and provide radiation shielding protection for the activities within this area. As a result the structural fire rating is equivalent to a 3-hour fire rating. However, the low combustible loading within this area and the surrounding areas requires less than a 1-hour fire rated barrier. Therefore, the penetrations into this fire area from doors, shield windows, ducting, etc., are rated for a 1-hour fire loading, or are constructed in a manner equivalent to a 1-hour rated structure. For the five fire zones within this fire area the worst-case fire loading amounts to less than a 30-minute equivalent fire duration.

Fire sprinklers are not provided within this area due to radiological concerns from spent fuel handling. Fire detection is provided throughout the area, with remote air sampling detection for the FPA where spent fuel is handled outside of any container and personnel access is highly restricted.

Fire loading outside this area is described in the Fire Area 3 fire zones discussion.

Fire Area 2 – Storage Vaults

Fire Area 2 consists of the ISF Facility storage vaults (storage vault 1 and storage vault 2). The purpose of this fire area boundary is to isolate ITS passive spent fuel storage areas from credible fires outside this area. The structural walls, floors, and ceiling surrounding this fire area are of reinforced concrete, and provide radiation shielding protection for the activities within this area. As a result the structural fire rating is equivalent to a 3-hour fire rating. However, the low combustible loading within this area and the minimal fire loading in surrounding areas requires less than a 1-hour fire rated barrier. Therefore, the penetrations into this fire area are rated for a 1-hour fire loading. The exterior wall air inlets and small annular gaps around each storage tube at the charge face are exceptions, discussed in Section 4.3.8.1.2. For the two fire zones within this fire area the worst-case fire loading amounts to less than a 10-minute equivalent fire duration. The only connecting structures to this area are the Transfer Tunnel (Fire Area 1) along the west side of the storage vaults, and the second floor storage area above. The remaining walls are exterior walls on the north, south, and east sides.

The storage vaults are a high radiation area and are not accessible once spent fuel is stored within the storage tubes. The 1-hour fire rated barrier between this area and surrounding areas ensures adequate fire protection from credible exposure fire hazards outside this area. Fire sprinklers and fire detection are not provided within this area due to lack of credible fire hazards in this area.

Fire loading outside this area is described in the Fire Area 1 and Fire Area 3 fire zones discussion.

Fire Area 3 – Remaining Areas

Fire Area 3 consists of the remaining ISF Facility structures (15 fire zones) and the general yard area. The purpose of this fire area boundary is to isolate Fire Areas 1 and 2 from exposure fire hazards and minimize the potential for radiological releases. The ISF Facility structures (15 fire zones) are Uniform Building Code (UBC) Type II non-combustible construction. The remaining structures that pose a potential exposure fire hazard to Fire Areas 1 and 2 are described in the general yard area fire zone discussion.

Cask Receipt Area (Fire Zone 1)

The Cask Receipt Area on the first floor contains ITS equipment/components and is separated from the adjoining Transfer Tunnel (Fire Area 1) by a 1-hour fire rated barrier or equivalent (if listed components are not available). The remaining walls are exterior walls, with no direct connection to other areas of the ISF Facility. The space is a steel frame structure with a metal clad wall panel system. The construction is equivalent to UBC Type II-N, with some upgrades as discussed below. Transfer Casks are brought into the space on a transporter truck and are unloaded with the cask lifting device. The casks are then placed on a trolley and are moved into the Transfer Tunnel.

The ITS items within this fire zone include the cask receipt crane (155-ton), the cask receipt crane lifting equipment, cask receipt crane support structures, and the Transfer Cask. The worst-case fire loading amounts to less than a 30-minute equivalent fire duration. The Transfer Cask fire resistance is described in Appendix A of this SAR. Generally, structural steel will maintain the ability to support design loading for direct exposure fires lasting up to 10 minutes without fire barrier protection. Therefore, the ITS structural steel supports within this area will be protected with 1-hour fire rated material up to a height determined by the Fire Hazard Analysis (FHA) to mitigate the postulated exposure fire concerns.

Fire detection and full sprinkler protection are provided within this fire zone.

Second Floor Storage Area (Fire Zone 2)

The second floor Storage Area contains ITS equipment and is separated from the adjoining Transfer Tunnel (Fire Area 1) by a 1-hour fire rated barrier, and from the storage vaults below (Fire Area 2) by a 1-hour fire rated barrier. The space is a steel frame structure with a metal clad wall panel system. The lower 9 feet of the walls are constructed of 2-foot thick reinforced concrete equivalent to UBC Type I fire resistive construction with a 3-hour fire rating. The upper steel construction is equivalent to UBC Type II-N. It provides weather protection for the CHM used to move ISF canisters from the Transfer Tunnel into the storage tubes.

The ITS items within this fire zone include the CHM, CHM rails, CHM grapple, ISF canisters (within CHM), and Storage Area fixed building ventilation (openings for natural circulation). The worst-case fire loading amounts to less than a 10-minute equivalent fire duration. The primary contributors to the fire loading within this area are the electrical cable insulation, hydraulics/lubricants, and neutron radiation shielding on the CHM. A significant portion of this combustible loading is the JABROC'N', which provides neutron radiation shielding for the CHM. The JABROC'N' material is a highly fire retardant wood-based product that will burn only when exposed to an external heat source. The material does not propagate fire and self-extinguishes. It would contribute heat only in the general area of another source fire. Other contributors to the combustible loading include high flashpoint lubricants in various machinery. The CHM is a massive structure that contains the grapple and ISF canisters; a postulated fire within this area would not adversely impact the ITS function of these items, including the support rails. The Storage Area fixed building ventilation is not susceptible to fire damage.

Fire detection is provided within this fire zone.

Operating Gallery (Fire Zone 3)

The operating gallery on the second floor does not contain ITS equipment, but does have ITS SSCs associated with the walls of the FPA and the CCA (Fire Area 1). The operating gallery is separated from the FPA and CCA by 1-hour fire rated barriers. In addition, the walls separating this zone from the Workshop (Fire Zone 4) and the Operators Office and Change Area (Fire Zone 5) are 1-hour fire rated barriers. The remaining walls are exterior facing walls with construction equivalent to UBC Type II-N. The space is used by personnel to operate the FPA manipulators and monitor progress of the packaging process.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 10-minute equivalent fire duration. The 1-hour fire rating for the Fire Area 1 boundaries will not be adversely impacted by this postulated fire.

Fire detection and full sprinkler protection are provided within this fire zone.

Workshop (Fire Zone 4)

The Workshop on the second floor does not contain ITS equipment, but does have ITS SSCs associated with the walls of the FHM Maintenance Area (Fire Area 1) including ITS components of the separating barrier. The Workshop is separated from the FHM maintenance area by a 1-hour fire rated barrier, including a door constructed in a manner equivalent to a 1-hour rated component. The wall between the Workshop and the corridor to the west is concrete block and is 1-hour fire rated, including the associated door. The wall between the Workshop and the operating gallery is gypsum and metal stud, and is 1-hour fire rated, including the associated doors. The exterior wall is constructed of steel framed metal clad panel protected with gypsum board for a 1-hour fire rating. The floor is concrete on metal deck and the ceiling is steel frame protected with gypsum, both maintaining a 1-hour fire rating. This fire zone is enclosed by 1-hour fire rated barriers or components constructed in a manner equivalent to a 1-hour rated structure, and uses construction equivalent to UBC Type II-1-hour.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 10-minute equivalent fire duration. The workshop area may contain materials that are radioactively contaminated; a concern exists for the potential spread of contamination from a fire in this area. Therefore, this fire zone is enclosed in a 1-hour fire rated boundary or equivalent construction.

Fire detection and full sprinkler protection are provided within this fire zone.

Operator's Office and Change Area (Fire Zone 5)

The Operator's Office and Change Area on the second floor does not contain ITS equipment, but does create an exposure fire hazard to the CCA, FHM Maintenance Area, and FPA (Fire Area 1). The Operator's Office and Change Area is separated from the CCA, FHM Maintenance Area, and FPA by 1-hour fire rated barriers. The remaining room outer walls are gypsum on metal stud. The rooms open into a walkway that connects the second floor operations area (Fire Zone 15) on the east side of the CCA with the operating gallery (Fire Zone 3) on the west side of the CCA. The wall separating the second floor operations area from this hallway is 1-hour fire rated. The wall separating the operating gallery from this hallway is 1-hour fire rated. The remaining walls are facing the exterior and are not fire rated.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, this fire zone is separated from Fire Area 1, Fire Zone 15, and Fire Zone 3 by 1-hour fire rated barriers.

Fire detection and full sprinkler protection are provided within this fire zone.

Electrical Room (Fire Zone 6)

The electrical room on the first floor does not contain ITS equipment, but does create an exposure fire hazard to the FPA, Transfer Tunnel, and CCA (Fire Area 1). The electrical room is separated from the FPA, Transfer Tunnel, and CCA by 1-hour fire rated barriers on the south and west sides. The north side, facing the exterior and the New Canister Receipt Area (Fire Zone 10), and the ceiling (concrete on metal deck) are 1-hour fire rated, including the associated doors. The east wall, connecting to the battery room (Fire Zone 7) is 1-hour fire rated. This fire-rated arrangement protects the upper levels of the FPA and CCA from this exposure fire hazard.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, this zone is separated from Fire Area 1 by a 1-hour fire rated barrier.

Fire detection and full sprinkler protection are provided within this fire zone.

Battery Room (Fire Zone 7)

The battery room on the first floor does not contain ITS equipment, but does create an exposure fire hazard to the FPA (Fire Area 1). The battery room is separated from the FPA by a 1-hour fire rated barrier on the southwest side. The north and east side, facing the exterior, the south wall (gypsum and metal studs), and the ceiling (concrete on metal deck) are 1-hour fire rated, including the associated door. The west wall connecting to the electrical room (Fire Zone 6) is 1-hour fire rated fire rated. This fire-rated arrangement protects the upper levels of the FPA from this exposure hazard.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, this zone is separated from Fire Area 1 by a 1-hour fire rated barrier.

Fire detection and full sprinkler protection are provided within this fire zone.

HEPA Filter Room (Fire Zone 8)

The HEPA filter room on the first floor does not contain ITS equipment, but does create an exposure fire hazard to the FPA and Transfer Tunnel (Fire Area 1). The HEPA filter room is separated from the FPA and Transfer Tunnel by 1-hour fire rated barriers on the north and west sides. The south side, facing the exterior, the east wall (gypsum and metal studs), and the ceiling (concrete on metal deck) are 1-hour fire rated, including the associated doors. This fire rated arrangement protects the upper levels of the FPA from this exposure hazard.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 10-minute equivalent fire duration. Therefore, this zone is separated from Fire Area 1 by a 1-hour fire rated barrier.

Fire detection and full sprinkler protection are provided within this fire zone. In addition, the enclosed HEPA filters within this area are protected by an automatic/manual deluge water spray system.

HVAC Exhaust Room (Fire Zone 9)

The HVAC exhaust room on the first floor does not contain ITS equipment, but does create an exposure fire hazard to the FPA (Fire Area 1). The HVAC exhaust room is separated from the FPA by a 1-hour fire rated barrier. The west wall connecting to the HEPA filter room (Fire Zone 8) and north wall connecting to the battery room (Fire Zone 7) are 1-hour fire rated, including the associated door. The remaining walls are exterior facing and are also 1-hour fire rated. This fire rated arrangement protects the upper levels of the FPA from this exposure hazard.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, the direct exposure fire hazard is adequately protected against by the 1-hour fire barriers and no credible exposure hazard from fire spread to the upper levels is possible due to the low fire loading within this area.

Fire detection and full sprinkler protection are provided within this fire zone.

New Canister Receipt Area (Fire Zone 10)

The New Canister Receipt Area on the first floor does not contain ITS equipment, but does create an exposure fire hazard to the Transfer Tunnel and CCA (Fire Area 1). The New Canister Receipt Area is separated from the Transfer Tunnel and CCA by 1-hour fire rated barriers. The south wall separating this area from the Solid Waste Storage Area (Fire Zone 11) and electrical room (Fire Zone 6) is also 1-hour fire rated. The remaining walls, ceiling and doors surrounding this area are not fire rated.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 15-minute equivalent fire duration. Therefore, the exposure fire hazard is adequately protected by the 1-hour fire barrier separation and the fire barrier envelope will minimize the potential for radiological releases from this area.

Fire detection and full sprinkler protection are provided within this fire zone.

Solid Waste Storage Area (Fire Zone 11)

The Solid Waste Storage Area on the first floor does not contain ITS equipment, but does present a potential for radiological release from a fire within this area, as well as an exposure fire hazard to a portion of the Transfer Tunnel (Fire Area 1). The Solid Waste Storage Area is separated from the Transfer Tunnel by a 1-hour fire rated barrier. The remaining walls, ceiling and doors, excluding the south wall, are 1-hour fire rated due to the potential radiological release concerns from a fire in this area. The south wall and associated doors are not rated as they separate this area from an associated SWPA (Fire Zone 12).

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, the exposure fire hazard is adequately protected by the 1-hour fire barrier separation and the fire barrier envelope will minimize the potential for radiological releases from this area.

Fire detection and full sprinkler protection are provided within this fire zone.

SWPA (Fire Zone 12)

The SWPA on the first floor does not contain ITS equipment, but does present a potential for radiological release from a fire within this area, as well as an exposure fire hazard to a portion of the Transfer Tunnel, FPA, and FHM Maintenance Area (Fire Area 1). The SWPA is separated from the Transfer Tunnel, FPA, and FHM Maintenance Area by 1-hour fire rated barriers. The remaining walls and ceiling with associated shield plugs, excluding the north and south walls, are 1-hour fire rated due to the potential radiological release concerns from a fire in this area. The north wall and associated doors are not rated as they separate this area from an associated Solid Waste Storage Area (Fire Zone 11). The south wall and associated penetrations are not rated as they separate this area from the Liquid Waste Storage Area (Fire Zone 13), which is another potentially contaminated area.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, the exposure fire hazard is adequately protected by the 1-hour fire barrier separation and the fire barrier envelope will minimize the potential for radiological releases from this area.

Fire detection and full sprinkler protection are provided within this fire zone.

Liquid Waste Storage Tank Area (Fire Zone 13)

The Liquid Waste Storage Area on the first floor does not contain ITS equipment, but does present a potential for radiological release from a fire within this area, as well as an exposure fire hazard to a portion of the Transfer Tunnel (Fire Area 1). The Liquid Waste Storage Area is separated from the Transfer Tunnel by a 1-hour fire rated barrier. The remaining walls, ceiling, and doors, excluding the north wall, are 1-hour fire rated due to the potential radiological release concerns from a fire in this area. The north wall and associated penetrations are not rated as they separate this zone from the SWPA (Fire Zone 12) which is another potentially contaminated area. The exterior wall on the south side is 1-hour fire rated to protect against exposure fire hazards from postulated vehicle fires outside this area as described in the yard area (Fire Zone 16) discussion.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 5-minute equivalent fire duration. No combustible materials are normally associated with this fire zone, but transient materials may be brought into the area and represent the only credible fire loading. Therefore, the exposure fire hazard is adequately protected by the 1-hour fire barrier separation and the fire barrier envelope will minimize the potential for radiological releases from this area.

Fire detection and full sprinkler protection are provided within this fire zone.

First Floor Operations Area (Fire Zone 14)

The first floor Operations Area does not contain ITS equipment, but does create an exposure fire hazard to the FHM Maintenance Area support structure (Fire Area 1) and the solid and liquid waste areas

(Fire Zones 11, 12, and 13). The entire east wall separating this fire zone from the Solid Waste Storage Area, Liquid Waste Storage Area, and SWPA (Fire Zones 11, 12, and 13) is 1-hour fire rated. The ceiling and exterior walls to the north, south, and west are not fire rated.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, the exposure fire hazard is adequately protected by the 1-hour fire barrier separation along the east wall.

Fire detection and full sprinkler protection are provided within this fire zone.

Second Floor Operations Area (Fire Zone 15)

The second floor Operations Area does not contain ITS equipment, but does create an exposure fire hazard to the FHM Maintenance Area (Fire Area 1). The second floor Operations Area is separated from the FHM Maintenance Area by a 1-hour fire rated barrier. The entire east wall separating this fire zone from the transfer area second floor (Fire Zones 4 and 5) is 1-hour fire rated. The ceiling, floor, and exterior walls to the north, south, and west are not fire rated.

The exposure fire hazard to Fire Area 1 from a worst-case fire loading amounts to less than a 45-minute equivalent fire duration. Therefore, the exposure fire hazard is adequately protected by the 1-hour fire barrier separation along the east wall.

Fire detection and full sprinkler protection are provided within this fire zone. Small rooms and inaccessible areas, such as an HVAC duct chase and cable chase, are not provided with suppression or detection.

ISF Facility Yard Area (Fire Zone 16)

The ISF Facility yard area contains the ITS seismic cutoff switch for power supplies in the switchyard area. The switchyard containing the seismic switch is located approximately 20 feet northeast of the Transfer Area of the ISF Facility at the closest point. A fire within this area could disable the seismic switch, but it is required to perform its isolation function only during an earthquake, which is not postulated to occur after a fire in this area. If an earthquake occurs first, then the seismic switch will perform its isolation function before any postulated fire that may occur as a result of the earthquake. Therefore, no fire-rated barriers are needed within this area to protect the seismic switch.

The remaining hazards in the ISF Facility yard area include possible exposure fire hazards to Fire Areas 1 and 2 from structures and components in the yard area. The five types of fire scenarios considered are structure fires, vehicle fires, diesel generator fuel fire, transformer fire, and a wildfire.

There are several support structures within the ISF Facility complex that do not contain equipment classified as ITS. A fire at these structures could create an exposure fire hazard for the ISF Facility and the associated ITS SSCs. The potential for a fire in the surrounding buildings to impact the ISF Facility was assessed using the guidance in National Fire Protection Association (NFPA) 80A-1996. The surrounding buildings include the Guard House, Visitor Center, administration center, and storage warehouse. These surrounding buildings were found to be adequately separated from the ISF Facility by the minimum required separation distance. Based on this finding, there is no postulated adverse impact to the ISF Facility from a fire in these surrounding structures.

The postulated vehicle fires are caused by the trucks used to deliver the spent fuel cask, process the liquid waste, deliver the new canisters, or provide other support services. The delivery access paths generally maintain a distance of 20 feet or more from the Transfer Area for vehicle traffic. However, access or processing locations do exist at points where items are brought into the facility. Locations where vehicles will routinely enter the ISF building have been addressed in the fire hazards discussion above for each access point. The access points outside the facility that are bounded by the internal access evaluations are the Cask Receipt Area and New Canister Receipt Area. The remaining access point is for liquid waste processing outside of the Liquid Waste Storage Tank Area. The waste truck processing location maintains at least 10 feet between a truck or fuel spill fire and the outer 1-hour fire rated wall of the Liquid Waste Storage Tank Area. The area around the truck is bermed to contain any potential flammable liquid spill and maintain the 10-foot separation distance. The 10-foot distance is typically sufficient to prevent flames reaching the building under windy conditions, based on the angle of the flame and the height of the building. The combination of a 1-hour fire rated barrier and 10 feet of separation from a postulated vehicle fire near the liquid waste storage area is adequate to protect against fire damage to this radiologically controlled area.

The diesel generator area in the switchyard area does not contain ITS equipment, but does create a potential exposure fire hazard to the ISF Facility. The potential explosion of the onsite diesel oil storage tank is not considered credible because of the low volatility and high flash point of the fuel. Diesel is not a flammable liquid but is classified as a Class II combustible liquid with a flash point between 100°F and 140°F. The fuel supply for the diesel generator is stored in a 1000-gallon double-walled Underwriters Laboratory (UL) listed storage tank. The fuel storage meets NFPA 30-1996 guidelines for flammable and combustible liquids storage. In addition, the separation distance from the diesel generator to the ISF Facility is greater than 20 feet, which provides additional protection for the Transfer Area and any ITS contents.

The transformer is located in the switchyard area and, as noted above, has the ITS seismic switch nearby. The remaining hazard from a fire in this area is the potential exposure fire concern for the Transfer Area located over 25 feet from the transformer. The transformer contains approximately 600 gallons of transformer oil. The type of oil is classified as “Less Flammable” per Factory Mutual (FM) Data Sheet 5-4 (2001). The minimum separation requirement per FM 5-4 for the transformer hazard is 25 feet for unapproved fluids and less for FM approved fluids (Ref. 8-14). The separation distance of 25 feet meets this minimum separation requirement and provides adequate protection of the ISF Facility from a postulated transformer fire.

Range wild fires ignited by lightning or human activity have occurred near or on the Idaho National Laboratory (INL) site. Some of the exterior walls of the ISF Facility are not fire rated; thus, accumulated weeds and brush could ignite and spread fire into the structure. The ISF Facility minimizes vegetation around the structures, by covering the area with gravel and by routine housekeeping. The gravel covered area extends from the outer fence line of the perimeter fence over the entire ISF Facility grounds. The minimum distance between the ISF building and the outer perimeter fence is over 100 feet. Due to the sparse vegetation and lack of trees outside the fence line, this is adequate to prevent a wildfire from exposing the ISF Facility to an external fire hazard.

As described above, non-combustible structural materials have been used throughout the ISF Facility, passive fire barriers are provided to separate fire hazards from ITS areas where possible, manual and automatic fire suppression capabilities are provided in key areas, and fire detection is provided in areas where significant fires are credible. In addition, the ISF Facility will utilize administrative controls to limit transient combustibles, control welding and hot work activities, and maintain housekeeping to further minimize the potential for fires.

Radiological Consequences

The temperature of the Transfer Cask, storage canister, or storage tube would not significantly change in the event of a credible fire in or outside the ISF Facility. Radiologically controlled areas are enveloped by fire-rated barriers to minimize the potential for offsite releases. Water used for fire suppression has been addressed in the criticality evaluations and will not create a potential for a criticality accident. Therefore, there are no postulated radiological releases or adverse radiological consequences from these events.

8.2.4.5 Maximum Hypothetical Dose Accident

Cause of Accident

This discussion describes a hypothetical, beyond design basis, non-mechanistic failure of the ISF canister confinement boundary and, separately, the ISF transfer area confinement boundary. These two events will bound an accident in either the interim storage configuration of the facility or the repackaging process at the facility. These hypothetical beyond design basis accident scenarios were selected to serve as worst-case conditions to bound the consequences of any credible accident at the ISF Facility involving the release of, and subsequent atmospheric dispersion of radioactive material.

Accident Analysis

Canister Leakage Under Hypothetical Accident Conditions

This evaluation assumes the canister is internally contaminated from failed fuel and the contamination is released to the environment. This scenario is conservative as there is no realistic mechanism for the particulate contamination to be released from the canister. Particulate contamination from spent fuel is the largest contributor to dose consequences from this hypothetical accident.

In this accident analysis, it is postulated that a canister leaks at the maximum rate permitted by the closure helium leakage test acceptance criteria for a 30 day period. Such a leak would require a significant defect in the multiple pass closure weld. In addition, the ISF canister would not likely be outside of a sealed storage tube for more than 24 hours after the seal welding is completed during normal packaging operation, thus making the 30 day release assumption conservative. In this accident condition, it is assumed that cladding/coating of 100 percent of the fuel elements stored in the canister have ruptured.

The SNF radionuclide release fractions are based on NRC Interim Staff Guidance-5 for accident conditions. Using the guidance of ANSI/ANS-5.10-1988 an atmospheric release fraction for a 30 day release of 0.0288 was determined. The ISF canister gaseous leak rate under the hypothetical accident conditions is 1.0×10^{-4} cc/sec. Dose conversion factors for internal dose due to inhalation and external dose due to submersion were obtained from EPA Federal Guidance Report No. 11. Environmental release factors considered in this analysis include:

- Release is at ground level (3 meters height) for maximum dose to receptor (2 meters height) at nearby locations as well as the controlled area boundary.

- Assume wind is blowing (2 m/s) toward the receptor locations to maintain suspension of the released material.
- Maximum allowed ISF canister leak rate release occurs over a 30 day period for this accident condition.
- The atmospheric stability class F was used and a χ/Q for the controlled area boundary of 8.48×10^{-6} s/m^3 was calculated.

This postulated non-mechanistic accident provides a bounding dose consequence case for the interim storage phase of operations at the ISF Facility.

ISF Transfer Area Release Under Hypothetical Accident Conditions

This postulated accident involves a loaded HEPA filter deflagration within the FPA followed by an assumed breach of the FPA confinement boundary. In order to develop the source term for this accident, radioactive contamination from fuel handled in the FPA is assumed to collect onto one of the five FPA HEPA exhaust filters up to an administrative exposure rate limit allowed for waste handling. In order to provide a mechanism for release from the facility, the loaded HEPA filter is assumed to undergo a deflagration. The deflagration in the FPA and the subsequent release from the FPA area are non-mechanistic as there are no known causes for such events.

The evaluation was performed separately for each of the SNF types. Radioactive contamination from a given fuel type was assumed to non-mechanistically accumulate on a HEPA filter until loaded to 250 mR/hr, on contact. This dose rate represents the maximum radiation level allowed by ISF Facility administrative procedures prior to FPA HEPA replacement (in practice, filter elements may be replaced more frequently based on differential pressure). The quantity of contamination (curies) required to reach the 250 mR/hr was determined for each of the fuel types to be repackaged in the FPA (TRIGA, Peach Bottom, and Shippingport Type IV Reflector Modules) using the radionuclide activities from Tables 7.2-1, 7.2-3, and, 7.2-4. The thickness and homogenized density of the contamination layer was determined by adding 30% air to the volume of the fuel element to account for loose packing during entrainment. Using MicroShield (version 5.05), a source term was calculated corresponding to the 250 mR/hr exposure rate on contact at the center of the HEPA filter face. The calculated source term amount for each of the fuel types was calculated to be 0.04 Ci for TRIGA fuel, 0.1 Ci for Shippingport Type IV Reflector Module, and 0.1 Ci for Peach Bottom fuel. The isotopic composition of the Peach Bottom fuel was selected since the TRIGA fuels and Shippingport Type IV Reflector Module are physically robust and not likely to result in dispersible material.

A non-mechanistic deflagration was then assumed to provide an energy source for the radioactive material release. Using the guidance of ANSI/ANS-5.10-1988 a deflagration release fraction of 1×10^{-2} was established. Thus, a 1×10^{-2} fraction of the material loaded on the HEPA filter was assumed to be released to the atmosphere as a result of the filter deflagration. No credit was taken for other ventilation exhaust HEPA filtration or the stack height to further minimize release consequences. Dose conversion factors for internal dose due to inhalation and external dose due to submersion were obtained from EPA Federal Guidance Report No. 11. Environmental release factors considered in this analysis include:

- Release is at ground level (3 meters height) for maximum dose to receptor (2 meters height) at nearby locations as well as the controlled area boundary.
- Assume wind is blowing (2 m/s) toward the receptor locations to maintain suspension of the released material.

- Release of the entire calculated source term was assumed to occur over a 2 hour period for this accident condition. .
- The atmospheric stability class F was used and a χ/Q for the controlled area boundary of 8.48 x 10^{-6} s/m^3 was calculated.

This postulated non-mechanistic accident provides a bounding dose consequence case for the SNF packaging phase of operations at the ISF Facility.

Radiological Consequences

The off-site radiological consequences of these non-mechanistic accidents were evaluated at the controlled area boundary. Based on the isotopic composition of the SNF types handled at the ISF Facility, Peach Bottom 2 fuel was identified as bounding for off-site dose consequences. The resulting dose for the ISF canister leak and FPA HEPA filter release at the closest controlled area boundary distance of 13,700 meters is 0.003 and 0.02 mrem TEDE, respectively. These calculated results are well below the 5,000 mrem accident dose limit of 10 CFR 72.106. Figures 8.2-1 and 8.2-2 provide dose results for distances closer to the ISF Facility for the bounding FPA HEPA filter release. The dose rates calculated for the nearer locations show that the resulting dose rates for workers at nearby facilities would be well below accepted regulatory limits.

8.2.5 External Events

8.2.5.1 Loss of External Power for an Extended Interval

Cause of Accident

The accident considered is the loss of external power supply to the ISF Facility for an extended interval. Extended is defined as any period greater than 24 hours without refueling the standby generator, with the potential to continue for an indefinite period of time. The cause of the event could be an offsite accident, equipment breakdown or malfunction, or a natural event resulting in a major failure of the power utility network outside of the ISF Facility.

Accident Analysis

As indicated in Section 8.1.5.2, ISF Facility operations are designed to shut down in a safe mode upon loss of power. The FPA is designed to remain at a neutral pressure with no breach of confinement, and therefore, no release of radioactive material. HEPA supply and exhaust filters and penetration seals remain in place and continue to function as confinement barriers. Standby power is available to operate one supply and one exhaust fan for a minimum of 24 hours without refueling, but is not required to maintain confinement or heat transfer. Manual capability is provided on transfer equipment to optimize shutdown conditions, but is not required for safe shutdown. Manual or standby operation of the transfer equipment will be suspended at temperatures below 32°F.

There are no adverse temperature concerns in the Cask Receipt Area, as it is designed for the highest or lowest postulated ambient temperatures. The loss of air circulation cooling or heating via the ventilation system would have minimal impact in the Cask Receipt Area and minimal impact on the in-process cask in the Transfer Tunnel. Thermal properties of the Transfer Cask are provided in Appendix A.

Conservative calculations indicate that the maximum fuel and facility structure temperatures for the bounding fuel types are at the fuel operations and monitoring station of the FPA. The bounding TRIGA fuel steady-state maximum temperature is 305°F and the bounding maximum concrete temperature for Peach Bottom fuel is 172°F. None of the in-process fuel locations with the planned fuel types exceed the lowest maximum allowable temperatures for either the fuel at 400°F or the ISF Facility structure (concrete) at 200°F.

The Storage Area is unaffected by loss of power, because in addition to safe design shutdown of equipment and facility services, the storage vault is designed for passive storage. The storage tubes are cooled by natural convection and require no electrical input to function. Air inlets and outlets are fixed geometry, requiring no electrical or mechanical input to operate.

If the loss occurs with the shipping cask or in-process SNF suspended by the cask receipt crane, the CHM, or the FHM, there is no requirement to continue operation to achieve safe shutdown status. However, a combination of standby power and manual operation are available to lower the SNF cask/containers to more stable positions. The standby power system is described in Section 4.1.2.3.4.

Radiological Consequences

The ISF Facility shuts down in a safe mode. There is no loss of confinement and fuel or facility temperatures will not exceed the allowable design parameters. Standby and UPS power is available to provide interim capability and services but these are not required for safe shutdown. There are no postulated radiological releases or adverse radiological consequences from this event.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

8.2.5.2 Earthquake

Cause of Accident

The design earthquake is assumed to occur and to act on the ISF structures and components.

Accident Analysis

The ISF Facility ITS SSCs have been designed and analyzed for a seismic event as described in Chapter 4. The response spectra were developed based on site-specific data and a probabilistic hazards analysis as described in Sections 2.6.2.4 and 3.2.3. The ITS SSCs are designed to withstand the stresses and accelerations associated with the design seismic event. There will be no damage to the SNF container or the SNF, and no impact on public health and safety as a result of the event. The seismic analyses for the major structures or components are discussed below.

Civil/Structural Analysis

The primary structural steel members, concrete structures, and footings for the areas encompassed by the Cask Receipt Area, the Transfer Area, and the Storage Area are designed to withstand the forces and accelerations associated with the design earthquake. The storage tube assemblies, including the canister storage tubes, shield plugs, and lids, which provide the vault storage positions, have also been designed to withstand these forces. In addition, the NITS primary structural steel members of the Cask Receipt Area, Transfer Area, and Storage Area have been designed using the same seismic criteria and load combinations as ITS structures. These structures will not adversely impact the SNF container or the SNF after a seismic event. The wall and roof panels and secondary support structures classified as NITS are not designed to withstand the design earthquake and may require repair or replacement after the event. These building components are not required to remain intact during the event and do not provide configuration control, confinement, support or structural protection for the SNF. Failure of these NITS systems would not result in damage to the SNF container or the SNF, and would not adversely impact public health and safety. The analysis of the ISF Facility structures is described in Section 4.7.3.3 and the analysis of the storage tube structures is described in Section 4.2.3.3. Based on these analyses, these systems will withstand the accident loads with no unacceptable consequences and no significant release of radioactive material.

Cask Receipt Crane Analysis

The cask receipt crane and supporting structural members in the Cask Receipt Area are designed to withstand the forces and accelerations associated with the design earthquake. The crane is designed to withstand the earthquake with cask loads of up to 155 tons. This is well above any load that will be supported during the currently planned campaigns. The crane remains in place and supports the suspended load through the design earthquake. The analysis of the cask receipt crane is described in Section 4.7.3.3.4. Based on this analysis, the crane will withstand the accident loads with no unacceptable consequences and no release of radioactive material.

Transfer Area Trolley Analysis

Both the cask trolley and canister trolley are designed to withstand the forces and accelerations associated with the design earthquake. With a fully loaded Transfer Cask or canister, the trolleys are designed to provide stable structures that prevent failure of, dropping, or significant damage to the SNF container. The analyses are described in Section 4.7.3.3.5 and 4.7.3.3.6. Based on this analysis, the transfer trolleys will withstand the accident loads with no unacceptable consequences and no release of radioactive material.

FHM Analysis

The FHM is designed to withstand the forces and accelerations associated with the design earthquake, without disengaging from the rails or dropping or damaging the SNF container. The FHM is operated within the FPA, which is a primary concrete structure that is also designed to withstand the event and to maintain confinement. The analysis is described in Section 4.7.3.3.7. Based on this analysis, the FHM will withstand the accident loads with no unacceptable consequences and without causing releases of radioactive material.

CHM Analysis

The CHM is designed to withstand the forces and accelerations associated with the design earthquake, without dropping or damaging the SNF canister. The analysis is described in Section 4.7.3.3.8. Based on this analysis, the CHM will withstand the accident loads with no unacceptable consequences and no release of radioactive material.

Ventilation System Analysis

The HVAC systems are not required to function during an earthquake. A seismic switch will automatically shut off the power to the facility in the event of an earthquake, causing the HVAC system to shut down. Components of the HVAC system that make up part of the Transfer Area confinement boundary are designed to withstand the forces and accelerations associated with the design earthquake. This includes the supply HEPA filters, the internal exhaust HEPA filters, and connecting ductwork, and components from the filters to the enclosure walls. The components are designed to maintain the functional integrity of the FPA confinement barrier during and after the natural phenomena event. They are not required to remain fully operational without repair or replacement. The component details and analyses are described in Section 4.3.1.1. Based on this analysis, the necessary HVAC components will withstand the accident loads with no unacceptable consequences and no release of radioactive material.

Radiological Consequences

The ITS structures and equipment have been designed to withstand the stresses and accelerations of the design earthquake. The earthquake will not breach confinement and will not damage the in-process or stored fuel or fuel containers. There are no postulated radiological releases or adverse radiological consequences from this event.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF.

8.2.5.3 Flood

Cause of Accident

The limiting flood conditions assumed for the ISF Facility are the result of the probable maximum flood (PMF). The PMF is postulated as the result of the overtopping failure of the Mackay Dam, upstream of the ISF Facility on the Big Lost River.

The sequence of events include a probable maximum precipitation event consisting of a 48-hour general storm, preceded 3 days earlier by an antecedent storm with a magnitude of 40 percent of the 48-hour storm. The postulated precipitation events would cause overtopping flow across the dam. The overtopping of the Mackay Dam is assumed to result in dam failure.

The PMF results in a flood elevation at the ISF Facility site of approximately 4921 feet, with water velocities of approximately 1 to 3 feet per second. The PMF elevation exceeds the elevation of the floor level for several facility areas. Details concerning the development of and basis for the PMF are discussed in Section 2.4.

Accident Analysis

The effects of hydrostatic and hydrodynamic forces on potentially affected ISF Facility SSCs were considered in the design. In general, these forces are insignificant as compared to other normal, off-normal, or accident loads on the affected SSCs. This evaluation concludes that the structural integrity of the ISF Facility confinement boundary would be maintained.

As identified in Table 2.4-3, the calculated time for the PMF wave to reach the ISF Facility is at least 13.5 hours. This provides sufficient time to implement preplanned flood control measures. These measures include putting any on-going processing sequences into a secure configuration and securing waste containers in the SWPA.

The Storage Area and the FPA are designed to prevent the ingress of floodwater. Penetrations and construction joints that are below the PMF in these areas are sealed to provide leak-tightness. The elevations of the various ISF Facility areas communicable with the floodwater and associated pathways are as follows:

Area	Elevation	Outside Portal Elevations	PMF Elevation Above Area Floor
Cask Receipt Area	4913’ – 2”	Below PMF	~ 7’ – 7”
Transfer Tunnel	4912’ – 6”	Below PMF	~ 8’ – 3”
Solid Waste Storage/SWPA	4917’ – 6”	Below PMF	~ 3’ – 3”
Liquid Waste Storage Tank Area	4915’ – 0”	Below PMF	~ 5’ – 9”
HVAC exhaust room	4917’ – 6”	Below PMF	~ 3’ – 3”

Flooding hydrostatic forces have been considered in the equipment designs for these areas, so any uplift will not damage equipment. Equipment such as the cask trolley, canister trolley, liquid waste storage tanks, and building structures include the flooding loads in their design basis.

In the event the PMF does occur, potential contamination from the above areas could possibly be transported via the floodwater to the offsite boundary. Each potential contamination site is discussed below.

Cask Receipt Area

- Transfer Cask – Incoming Transfer Casks will have been verified to be clean from radioactive contamination before receipt within the ISF Facility. Outgoing Transfer Casks will be decontaminated if any loose external radioactive contamination is identified by routine surveys. The cask will remain sealed while in this area, so internal contamination will not be subject to flood water conditions.
- General area contamination – This area is a clean area and will be maintained free of loose radioactive contamination throughout the life of the ISF Facility. The cask trolley and Transfer Cask delivery/removal transport will be maintained free of radioactive contamination down to background levels.

Transfer Tunnel

- Peach Bottom Transfer Cask – If contamination occurs while removing SNF from the Transfer Cask, it will be decontaminated before release from this area back to the Cask Receipt Area. The process steps in the transfer tunnel are designed to minimize the potential for contamination. The normal radiological controls will minimize the loose contamination potentially present during flood conditions.

- Tunnel floor and walls – Normal radiological controls will monitor and remove loose radioactive contamination on the floor and walls of this area.
- Cask trolley – Normal radiological control during processing and use of the trolley will monitor and remove loose radioactive contamination on exterior surfaces of the trolley that could come in contact with flood waters.
- Canister trolley – Normal radiological control during processing and use of the trolley will monitor and remove loose radioactive contamination on exterior surfaces of the trolley that could come in contact with flood waters. Some contamination may be present on the inside surface of the canister heater module. Contamination of the inside surface of the canister is considered unlikely. The lower elevation of this canister cask in the trolley is below the flood level when in the lowered position. The design of the canister cask includes a water tight seal for any bottom joints as well as the side joints to prevent flood water contact with the potentially contaminated interior surfaces or the ISF canister.

Other areas where flooding may occur include:

- Liquid Waste Storage Tank Area
    - General area contamination – The tanks, pipes, pumps, and valves within this area will be leak tight to prevent the spread of contamination. Normal radiological control during processing of liquid waste will monitor and remove loose radioactive contamination on exterior surfaces of the equipment that may come in contact with flood waters.
- Solid Waste Storage Area
    - Waste containers – The waste containers will be sealed and smeared for loose radioactive contamination to ensure the containers are suitable for shipment. No loose contamination will be present on the exterior of these containers that could act as a source term for release during a flood event. The contaminated interior of the containers will not be exposed to the flood waters.
    - General area contamination –The floor and walls will be surveyed periodically and decontaminated as necessary. Loose contamination that could act as a source term for release from exposure to flood waters will be removed.
- SWPA
    - Waste containers – The waste containers will be sealed and smeared for loose radioactive contamination to ensure the containers are suitable for shipment. No smearable contamination will be present on the exterior of these containers that could act as a source term for release during a flood event. The contaminated interior of the containers will not be exposed to the flood waters.
    - General area contamination – There will be no surface contamination in the outer work areas of the SWPA. These work areas will be surveyed periodically and decontaminated as necessary. Loose contamination that could act as a source term for release from exposure to flood waters will be removed.

- HVAC exhaust room
  - General area contamination – The HEPA filters inside the ductwork within this area may become contaminated during normal operations. However, the external surfaces of the HVAC systems are not expected to be contaminated. The ducting around the potentially contaminated HEPA filters is a leak tight system. Based on this design, the contamination present will not act as a source term for release from exposure to flood waters.

This event involves no change to the fuel or structural configuration. Therefore, there is no change in criticality, confinement, or retrievability of the spent nuclear fuel.

Radiological Consequences

No source of radiological contamination has been identified from the above assessment of the flooding impact on each affected ISF Facility area. In addition, operating instructions will be provided to secure operations in potentially wetted areas upon warning of an impending flood. The amount of time available before flood waters could reach the facility will allow actions to be taken for securing operations and preventing local flooding of potentially contaminated areas. This will further ensure that no adverse radiological consequences result from this event.

8.2.5.4 Extreme Wind

Cause of Accident

In accordance with ANSI-57.9 and 10 CFR 72.122, the ISF Facility is designed for tornado effects, including tornado wind loads and credible tornado missiles. The design basis tornado (DBT), as discussed in Section 3.2.1.1.2, has a maximum wind speed of 200 mph. A pressure drop across the tornado of 1.5 psi was assumed in accordance with NRC Regulatory Guide 1.76 (Ref. 8-15). The DBT missiles are taken as Spectrum II missiles in Region III and are presented in Table 3.2-1. Extreme wind is classified as a natural phenomenon Design Event IV as defined in ANSI-57.9.

The ISF Facility is constructed at the INL site, near Idaho Falls, Idaho, approximately 43°34' north latitude and 112°55' west longitude. Data on actual tornado occurrences and estimates of the probability of a tornado of various sizes occurring at locations throughout the United States have been published in NUREG/CR-4461, *Tornado Climatology of the Contiguous United States* (Ref. 8-16). The data indicate that the INL site area is one of the lowest tornado hazard areas in the United States. The average probability of any tornado occurring within this geographic region is 6.0×10^{-7} yr^{-1}. The probability that a tornado of category F-2 or higher (wind speeds in excess of 113 mph) will occur is estimated to be 1.69×10^{-7} yr^{-1}, and the maximum wind speed that will occur with a probability of 1×10^{-7} yr^{-1} is estimated to be 171 mph (category F-2). NRC Guidance specifies tornado missile-induced events with a probability of occurrence less than 1×10^{-7} yr^{-1} need not be considered when evaluating ITS SSCs (Ref. 8-17 and 8-18).

Accident Analysis

The ISF Facility has been designed and analyzed to withstand the effects of extreme wind conditions generated by severe natural phenomena. These include high wind pressure loadings, differential pressure, and credible wind-generated missiles.

The full list of Spectrum II missile details and associated velocities include:

- 115-pound wooden plank traveling at 190 feet/sec
- 287-pound 6-inch diameter steel pipe traveling at 33 feet/sec
- 9-pound 1-inch diameter steel rod traveling at 26 feet/sec
- 1124-pound utility pole traveling at 85 feet/sec
- 750-pound 12-inch diameter steel pipe traveling at 23 feet/sec
- 4000-pound automobile traveling at 134 feet/sec

The DBT load combinations are defined in Section 3.2.1.2. Analyses of the missile spectrum indicate that the heavier missiles will not be generated by wind speed less than 200 mph. The large missiles such as the utility pole and 12-inch steel pipe are not credible missiles (Ref. 8-19). The automobile sized missile will not be picked up or sustained by tornado events with wind speeds of 200 mph or less (Ref. 8-20). Therefore, the tornado missile analysis addresses the light object missiles (wooden plank, 6-inch steel pipe, and 1-inch steel rod).

The acceptance criteria for the analysis of the DBT are to ensure that ITS SSCs can perform their function during and following a DBT. These include SSCs required to protect or maintain confinement of the spent fuel, prevent criticality, and ensure adequate shielding. The ISF Facility design provides confinement barriers with sufficient structural capacity to withstand the DBT loadings, or through the provision of tornado missile barriers with sufficient structural capacity to withstand the DBT loadings and protect the confinement boundary. Analysis of the DBT missile loadings has determined:

- minimum thickness of steel to prevent local perforation is 0.08 inches
- minimum thickness of concrete to prevent scabbing is less than 7 inches
- a reinforced concrete wall 12 inches thick is acceptable for DBT missile protection

The confinement boundaries for the ISF Facility are defined in Sections 4.2.2.3 and 4.7.2.3. The confinement boundaries and the corresponding DBT missile protection features are summarized in Table 8.2-1. DBT protection for the various ISF Facility areas and configurations is discussed below.

For the cases discussed below, the potential for criticality is bounded by the evaluation presented in Section 4.7.3.4. That evaluation assumes optimum spacing, flooded conditions where appropriate, and full reflection. These conditions cannot be met or exceeded under any of the cases discussed below. Therefore, the SNF would remain subcritical for the cases discussed below.

Case 1 - Outside Receipt Area

While the Transfer Cask is inside the site boundary but outside of the Cask Receipt Area, DBT protection is provided by the Transfer Cask. The analyzed configuration consists of the Transfer Cask secured to the transporter. The loadings for this configuration and the results of the analysis are provided in Appendix A of this SAR.

Case 2 - Inside Receipt Area, Transfer Cask on Transporter, Unsecured with Impact Limiters Removed

Case 2 assumes the Transfer Cask is on the transporter, but within the Cask Receipt Area with the cask hold-downs removed. As in Case 1, the confinement boundary is provided by the Transfer Cask. DBT loadings were applied in the design of the Cask Receipt Area structure primary steel; therefore, this structure is not assumed to fail and impact the Transfer Cask during this event. The impact of non-structural members of the Cask Receipt Area (e.g., the sheet metal siding) is bounded by the Spectrum II missiles assumed in the analysis. Therefore, analyses of the DBT loadings remain limited to the loadings identified in Table 3.2-1. The results of the analysis of this configuration are bounded by Case 1 and are provided in Appendix A of this SAR.

Case 3 – Inside Receipt Area, Suspended by Crane, Impact Limiters Removed

Case 3 assumes the Transfer Cask is suspended by the cask receipt crane with the impact limiters removed. The direct effects of DBT winds, pressure, or missiles are not included in the design loads for the hoist. The base fuel receipt schedule indicates 178 fuel shipments over an 1186-day period. Each shipment will take less than 1 day to process into the facility, but 1 day will be conservatively assumed for the purposes of this analysis. Therefore, the ISF Facility will be handling fuel approximately 15 percent of the calendar days in the base operating period. The joint probability that the ISF Facility will be handling fuel on the day that a tornado may potentially occur is ($0.15 \times 6 \times 10^{-7}$) 9.01×10^{-8}, (less than $1 \times 10^{-7}\ yr^{-1}$). Therefore, this is not considered a credible event, and the effects of tornado winds, pressures, and missiles have not been considered in the design of the cask receipt crane. As an additional precaution, administrative controls will be used to restrict SNF handling operations during periods when tornado watches or warnings are in effect.

The supporting structure for the cask receipt crane has been designed to withstand the effects of tornado winds, pressure, and appropriate Spectrum II missiles, providing an additional degree of assurance that the hoist will remain supported during a tornado event and not pose a collapse threat to the cask below.

Case 4 – Inside Receipt Area, in Cask Trolley

Case 4 assumes that the Transfer Cask is in the Cask Receipt Area secured in the cask trolley with the cask adapter and hold-downs in place. In this configuration, further protection from DBT missile impact is provided by the cask trolley structure itself. Assuming the cask trolley provides no additional missile impact protection, the DBT loadings on the Transfer Cask itself remain unchanged.

The 24-hour processing time for each shipment to be moved into the protected areas of the ISF Facility described in Case 3 above includes this stage of processing. Therefore, this is not considered a credible event, and the effects of tornado winds, pressures, and missiles have not been considered in the design of the cask trolley. As an additional precaution, administrative controls will be used to restrict SNF handling operations during periods when tornado watches or warnings are in effect.

Case 5 – Inside Transfer Tunnel in Cask Trolley, Transfer Cask Bolts Removed

After the Transfer Cask is loaded onto the cask trolley, the cask trolley advances to the cask decontamination zone in the Transfer Tunnel. Here, the bolts are removed from the Transfer Cask, and the cask adapter is relied upon to maintain the confinement boundary.

The Transfer Tunnel itself is constructed of reinforced concrete with a minimum thickness of 3 feet, providing a sufficient barrier for DBT loadings. The Transfer Tunnel contains two doors: the outer door is at the Transfer Tunnel entrance in the Cask Receipt Area; the inner door segregates the decontamination zone from the remainder of the Transfer Tunnel. The Transfer Tunnel outer door is designed to prevent missile impacts on equipment inside the Transfer Tunnel. The maintenance hatch above this area that provides access between the Transfer Tunnel and the second floor storage area is designed to withstand postulated missile impacts. Therefore, the cask trolley and Transfer Cask are protected from further postulated missile impacts after they are moved into the Transfer Tunnel and the outer door is closed.

Case 6 – Inside Transfer Tunnel in Canister Trolley

In Case 6, the SNF has been loaded into the ISF storage canister contained in the canister trolley. The ISF storage canister may be positioned under the FPA canister port, enroute to the welding port under the CCA, positioned under or raised into the CCA welding port, enroute to the Storage Area port, or under the Storage Area port. These configurations are protected from postulated missile impacts by the reinforced concrete walls surrounding the Transfer Tunnel and the outer door between the Transfer Tunnel and the Cask Receipt Area.

Case 7 – Fuel Packaging Area

The FPA is an isolated area enclosed by reinforced concrete walls 4 feet thick. The HEPA filters within the FPA and the tornado dampers outside of the FPA including intervening ductwork provide the confinement boundary for the FPA during postulated tornado events. The HEPA filters are protected from DBT wind and pressure differential loading conditions via tornado differential pressure dampers that close upon high differential pressure. The tornado dampers located outside of the FPA are locally protected from DBT missiles. The ductwork is offset through the FPA wall to provide shielding to limit dose and protect the tornado dampers within the FPA from DBT missiles. Electrical penetrations are similarly installed offset to provide radiation shielding that protects against tornado-driven missiles. The shield windows have been evaluated and determined to withstand the impact of tornado-generated missiles, wind, and differential pressure without breaching the confinement barrier they provide. the transfer tunnel is protected from DBT effects by the outer door, protecting the FPA port plugs from DBT effects. Therefore, the FPA confinement boundary would be maintained.

Case 8 – Canister Closure Area

The CCA is an isolated area enclosed by reinforced concrete walls that are a minimum of 3 feet thick. This area is not a confinement boundary, but does contain the upper portion of an ISF canister, which performs that function during closure welding of the canister. A single viewing window provides the only credible opening within the concrete surroundings that could allow a missile to hit the ISF canister. The doors into the area are at each end of the area and no credible missile angle of attack would reach the ISF canister port area (near the center of the room) due to labyrinth barrier walls. The ISF canister shield plug and surrounding canister cask provide the necessary protection from a missile strike through the single viewing window. The viewing window would reduce the kinetic energy of credible tornado-driven missiles into this area. The small area of the target created by the ISF canister in the center of this area would further minimize the potential for a missile to strike the canister. However, such a strike would, at most, cause canister shell distortion that would require repackaging of the affected spent fuel into a different canister. The potentially exposed areas of the canister are well above the protected fuel portion of the canister within the 9-inch thick carbon steel canister cask. No damage to the fuel or offsite releases are postulated for such an unlikely impact.

Case 9 – Canister Handling Machine in Second Floor Storage Area

The CHM has been designed to withstand the effects of tornado winds and pressures. Although it is likely that the CHM will withstand the effects of tornado missiles, tornado missile loads have not been explicitly incorporated into the design calculations for the hoist and CHM control systems. The CHM will be used to insert up to 246 canisters into the storage tubes over a minimum operating period of 39 months (1186 days). Each fuel storage operation of the CHM is postulated to be completed within 1 day. Therefore, the CHM will be handling fuel that must be protected from tornado missiles less than 21 percent of the calendar days of the operating period. This results in a joint probability of a tornado occurring of sufficient strength to generate tornado missiles during fuel handling operations of ($0.21 \times 1.69 \times 10^{-7}$) 3.6×10^{-8}, which is not considered credible. Therefore, the CHM is not required to be designed to withstand the effects of tornado missiles while it is used to handle SNF canisters. As an additional precaution, fuel handling operations will be administratively restricted when tornado watches or warnings are in effect.

Case 10 – Storage Area

The Storage Area is enclosed by 3 foot thick reinforced concrete walls up to 30 feet around the perimeter. The charge face area is protected by the concrete thickness between storage tubes (over 2 feet) or the tube cover plates. The tube cover plates are approximately 2.25 inches thick steel, bolted down over each storage tube. This construction is sufficient to protect against postulated missile strikes.

Case 11 – Solid/Liquid Waste Areas

The Solid Waste Storage Area is protected on the south and east sides by thick concrete walls that are resistant to tornado missiles or high winds. Only the north and west walls and ceiling are prone to damage from a tornado missile or high winds. The SWPA is enclosed on four sides and the ceiling by thick concrete walls that are resistant to tornado missiles and high winds. However, a door on the north wall is susceptible to damage from a tornado missile or high winds. The Liquid Waste Storage Tank Area is protected on the north and east sides by thick concrete walls that are resistant to tornado missiles or high winds. Only the south and west walls and ceiling are prone to damage from a tornado missile or high winds.

As stated in Regulatory Guide (RG) 1.117, “It is generally not necessary to protect the radioactive waste systems since, even in the event of gross failure, offsite exposures would remain well below the guideline exposures of 10 CFR 100 because of the limited inventory allowed in these systems.” (Refs. 8-17 and 8-21). At the ISF Facility, the solid waste will be packaged into steel drums or boxes soon after receipt. The waste packages will be sealed and the exterior surfaces will be smeared for removable contamination, and decontaminated if needed. Any surface contamination in the outer work areas of the SWPA will be decontaminated as needed during routine survey activities. The amount of contamination that could be removed from this area by tornado winds as a result of residual contamination would be minor.

A tornado-generated missile may puncture one or more of the sealed waste containers. The low pressure generated by the tornado may then release some of the material from the damaged container. The amount of contaminated material that may be released from this event could cause some localized contamination near the ISF Facility, but will not represent enough material to cause a significant off-site dose to the public.

This event involves no change to the fuel or structural configuration. Therefore, there is no change in criticality, confinement, or retrievability of the SNF.

Radiological Consequences

The analysis of the ISF Facility under DBT loadings has determined that the confinement boundary would be maintained for each spent fuel configuration. Therefore, no release of radiological material from within the confinement boundary is assumed to occur. As described above the DBT effects on the waste storage area has determined that insignificant dose consequences would result.

8.2.5.5 Lightning

Cause of Accident

This event would be caused by adverse meteorological conditions.

Accident Analysis

A lightning risk assessment has been conducted for the ISF Facility in accordance with the *Standard for the Installation of Lightning Protection Systems*, NFPA 780-1997. This risk assessment calculated a moderate to severe lightning risk factor for the ISF Facility site. Although the effects of a lightning strike are not expected to be significant, a lightning protection system is provided to further reduce the risk. Section 4.3.8.1.4 of the SAR describes the lightning protection requirements for the ISF Facility design.

Lightning strikes near the ISF Facility will not affect normal operations. The lightning protection system provides a low impedance path to ground from the upper elevations of the ISF Facility structures. The structural steel and reinforced concrete surrounding the spent fuel provides an added factor of safety for protection of the SNF from the effects of lightning strikes. The SNF does not rely on ventilation systems or other equipment to remove the decay heat, so equipment failures due to current surge from a lightning strike would not affect the integrity of the spent fuel. The SNF is packaged and stored entirely within the ISF Facility, which is enveloped by lightning protection designed in accordance with NFPA 780-1997. The Transfer Cask will be located outside the ISF Facility for a brief period when the SNF is first received. The Transfer Cask lightning protection is described in Appendix A of this SAR.

Radiological Consequences

There are no radiological consequences for a lightning strike, as confinement of the SNF will be maintained.

8.2.5.6 Accidents at Nearby Sites

Cause of Accident

The INL site is large and remote as described in Section 2.1. Facilities within 5 miles of the ISF Facility have been evaluated per NRC guidelines and include the Central Facilities Area (CFA), Test Reactor Area (TRA), and Power Burst Facility/Waste Experimental Reduction Facility (PBF/WERF) (Ref. 8-11). In addition, several installations within INTEC contain radiological, chemical, and toxic hazardous materials. The nearest public transportation route is approximately 4 miles south of the ISF Facility, and the nearest railroad line is approximately 7 miles south of the ISF Facility.

Accident Analysis

The CFA poses no radiological, toxic, or hazardous chemical concern to the ISF Facility, because it provides only centralized support services for INL operations (e.g., medical services, vehicle maintenance, machine shops, and environment sample analysis). Radiological consequences from accidents at PBF, TRA, and INTEC facilities are periodically reviewed and updated for emergency planning purposes. Because of the distance between the ISF Facility and other INL facilities, airborne contamination is the primary potential consequence of an emergency condition at one of the nearby nuclear facilities. Certain radiological accidents postulated at the nearby facilities would result in evacuation of the ISF Facility due to high dose rates (Ref. 8-13 and 8-22). Radiological, chemical, or toxic material hazards are addressed by the INL emergency plan and the ISF Facility would be notified of the appropriate protective actions by the Warning Communication Center (WCC) at DOE-ID. Transportation accidents are far enough away that no adverse consequence from such an accident is credible (Ref. 8-23).

Radiological, chemical, or toxic materials accidents from nearby facilities are not postulated to cause damage to the ISF Facility. The worst case postulated accidents protective actions could result in personnel evacuation from the ISF Facility. This would be done in accordance with the ISF emergency plan.

Radiological Consequences

Radiological impacts on the ISF Facility from off-site nuclear facilities are addressed by the INL emergency plan. The passively safe nature of the ISF Facility will allow personnel evacuation without adverse impacts on the confinement barrier. If needed, the ISF Facility would be decontaminated as part of the general recovery from the off-site nuclear accident.

8.2.5.7 Volcanism

8.2.5.7.1 Volcanism – Basaltic Lava Flow

Cause of Accident

As discussed in Section 2.6.6.4 the risk of basalt-lava inundation or intrusion related ground disturbance is estimated to be less than $1x10^{-5}$ per year, which makes it an extremely unlikely event. However, if it were to occur it could potentially affect the facility and therefore is addressed further in this section.

Accident Analysis

Total warning time from identification of magma-induced seismicity to arrival of lava in the vicinity of the ISF Facility would be substantial, likely ranging from 1 week to over a month. If magma-induced seismic activity is detected by the INL Seismic Monitoring Program instrumentation, INL WCC would be notified. The equipment and workforce needed to construct a barrier would be obtained within a week, if necessary to protect the ISF Facility.

The distance from the volcanic event would likely be at least 10 kilometers (fiftieth percentile length), and more likely about 16 km (seventieth percentile length). The effusion rate would likely be waning by the time it reaches the ISF Facility area. Analogy to flow velocities in other areas with similar terrain indicates that velocities of about 2 kilometers per day are most likely. Therefore, it would take several days for lava from most of the critical volcanic source area to reach the site.

Assuming the above advance warning of an impending event, two potential diversionary measures are identified in Sections 2.6.6.2.4; earthen diversionary structures and cooling water sprays. Both approaches have been implemented previously to protect structures from lava flows, either separately or in combination.

The ISF Facility site is located close to the protected area of INTEC, and is surrounded by DOE-owned facilities and structures associated with the INTEC. Volcanic activity that could directly affect the ISF Facility is treated as a Site Area Emergency under the *ISF Facility Emergency Plan* (see Section 4.7 of the referenced plan). Site Area Emergency responses under the *ISF Facility Emergency Plan* (Ref. 8-33) are coordinated with and through the DOE-ID Emergency Response organization as described in the *ISF Facility Emergency Plan* and the *INL Emergency Plan/RCRA Contingency Plan* (Ref. 8-29). DOE will take independent action to respond to a lava flow event that could potentially threaten the INTEC facility. Should such action be warranted, the following sections discuss the actions required to protect the ISF Facility on a stand-alone basis.

Diversionary Structure Design and Construction Features

The proposed diversionary structure would be a 20-foot-high earthen berm constructed in a manner that would divert lava flow away from the ISF facilities. The density of the lava is assumed to be 165 lbs/ft^3, similar to basaltic rock. It is assumed that the entire perimeter of the facility would be protected from a lava flow with a thickness of up to 20 feet. As indicated in Section 2.6.6.2.3, the upper bound lava thickness identified in boreholes is 33 feet, however, the median lava flow thickness in the Eastern Snake River Plain is about 12 feet (Ref. 8-30). The proposed size of the berm is, therefore, sufficiently bounding for lava flows that may exceed the median thickness, with margin.

Protecting the entire facility perimeter would require a berm with an approximate total length of 2,000 feet, assuming that the berm was positioned within the exclusion area boundary (see Figure 4.1-1). The total berm height would be 20 feet with a width of 132 feet at the base and 12 feet at the top, with side slopes of 3 feet horizontal to 1 foot vertical. The total estimated soil volume, accounting for compacting and a contingency, required to complete the berm is 136,000 cubic yards.

Soils for the berm would be excavated from areas immediately adjacent to the ISF Facility site. Section 2.6.1.3.3 indicate that soils in the immediate vicinity of the ISF Facility site are dense sandy gravels, dense sand, and gravel. As noted in Section 2.6.1.3.1, this is consistent with the alluvial silts, sands, and gravels found in the subsurface throughout the vicinity of INTEC. This soil, when placed in 12-inch lifts and compacted to 85% to 90% of the maximum density, will provide for a strong earth structure capable of withstanding the forces of the lava flow.

Construction of the berm will require a continuous cut and fill operation. Fill soil will be cut from a nearby location and placed within the exclusion zone boundary. A crew consisting of five scrapers (1,100 CY/day each), two sheepsfoot compactors, a water truck, and a motor grader can place approximately 5,500 CY/day. Assuming that this crew size is operated over three shifts, approximately 16,500 CY of soil can be placed and compacted per day. Placement to the final height can be accomplished in 8 to 10 days; given several weeks notice of an impending eruption, this timeframe is anticipated to be adequate to ensure protection of the ISF facilities.

Water Cooling System Design and Construction Features

Sigurgeirsson (Ref. 8-32) reported that cooling water used to control the 1973 Elfell Volcano in Iceland was applied at the rate of 10.7 gal water/ft^3 lava (1 m^3 water/ 0.7 m^3 lava). The maximum pumping rate used ranged from 11.5 to 23 Mgal/day.

The water-cooling system would consist of piping to convey water from the site fire protection system and other nearby groundwater sources. The existing INTEC fire storage, pumping, and distribution system is capable of supplying up to 7.2 Mgal/day, assuming two fire pumps providing 2,500 gal/min each at 125 lb/in^2. Nine wells within 5 miles of the ISF facility are capable of providing a total of up to 14.4 Mgal/day for up to several weeks. Assuming the above cooling water application rate, with 14 Mgal/day of water available, a 20 ft high by 10 ft thick section of lava could be cooled every day along a 4,000 ft front. This performance is anticipated to be adequate to divert a lava flow around the ISF facility.

Constructing the water pumping system will require installing piping, hoses, fittings, and other appurtenances. Since the ISF fire protection system can only provide one half of the necessary flow, water from other nearby production wells will need to be conveyed to the ISF Facility. It is estimated that approximately 13,000 linear feet of 6- to 8-inch piping and hoses are needed to pump water from these INL site production wells.

Within the ISF Facility, 3,300 linear feet of 6- to 8-inch quick-disconnect irrigation, plastic water pipe, or flexible hoses will be placed from the four existing fire hydrants. Appurtenances would include valves, pipe anchors, and spray or jet nozzles.

Supporting construction equipment would include a crew with a hydraulic excavator, front-end loader, and backhoe/loader. Using this crew size, the required piping and hose described above can be installed in 18 to 20 days, assuming 900 ft/day of pipeline is constructed; given several weeks notice of an impending eruption, this timeframe is anticipated to be adequate to ensure protection of the ISF facilities. Temporary aboveground piping would be covered with fill soil.

Evaluation of Potential Effectiveness of Proposed Structures

The ability to effectively implement intervening measures depend primarily on the distance from the erupting volcanic vents, the morphology of the zone through which the lava flows, and the speed of the advance (Ref. 8-25). Given the site-specific factors at the ISF Facility site, intervention measures are likely to be possible.

Slowing and diverting lava flows with earthen berms has been attempted in other volcanic eruptions. As an example, during the 1983 eruption of Mt. Etna, diversion barriers 100-ft-wide by 30-ft-high by 1,200-ft-long were successful in slowing and diverting a 7 km long lava flow of approximately 100 million m^3, effusing at a rate of approximately 8.9 m^3/s (770,000 m^3/day). Sufficiently dense soil material and good construction techniques contributed to this success. Barriers built in front of a lava flow on Kilauea in the 1970s did not divert the advancing lava flow. Failed attempts appear to have been a function of unsuitable material (such as volcanic ash) and inappropriate placement techniques. The placed densities of the available onsite borrow material and provisions for proper placement and compaction will provide for a strong earthen barrier capable of withstanding the forces of the lava flow. In general, however, even berms constructed of less-suitable materials appear to fail more frequently by overtopping, versus structural failure of the berm (Ref. 8-25). Therefore, it is anticipated that this diversionary technique will be effective if implemented at the ISF Facility site.

In addition to the experience with volcanoes in Iceland cited earlier, cooling water sprays have been successfully used to divert or slow lava flows during the eruption of Kilauea in 1960 (Ref. 8-24), in Japan in 1986 (Ref. 8-26), and at Mt. Etna in 1983 (Ref. 8-25). In the unlikely event that such actions were needed, it is anticipated that this diversionary technique would be effective if implemented at the ISF Facility site, particularly in combination with an earthen berm structure.

Evaluation of Sufficiency of Resources to Implement Lava Flow Diversionary Measures

In the unlikely event that a lava flow threatened the ISF Site and adjacent DOE facilities, the DOE INL response would include the ISF Facility. Adequate time is available for implementation of mitigation actions within the warning timeframe on the order of four to six weeks to preclude any impact on the ISF Facility. Therefore, recovery from this unlikely event is not required.

Radiological Consequences

In the unlikely event of a future basaltic lava flow, the ISF Facility would experience no structural, thermal, or radiological consequences due to the implementation of the above mitigation actions.

8.2.5.7.2 Volcanism - Ash Fall

Cause of Accident

As discussed in Section 2.6.6.3.3, Hoblitt (Ref. 8-34) modeled the annual probability of 1-10 cm of volcanic ash over the northwestern United States from Cascade eruptions as a function of which centers had historically produced ash, the frequency of eruptions of various sizes, and dominant wind directions for the Cascades. Based on this modeling, the probability of 1 cm of ash-fall in southeast Idaho is approximately 5×10^{-3} per year. The same model suggests that the probability for 10 cm of ash-fall from a Cascade volcano in southeast Idaho is approximately 10^{-6} per year. Correlating ash-fall thickness to probability, a Cascade eruption that could deposit 8 cm or more of ash at INL would also have a probability of approximately 10^{-6} per year. This is consistent with one Cascade eruption depositing up to 6 cm of uncompacted ash in the Eastern Snake River Plain over the past 400,000 years.

Table 8.2-2 provides a summary of the estimated probabilities of various ash-fall events that may potentially impact the ISF Project site.

Accident Analysis

Analysis of Ash Fall Impacts on Structures, Systems and Components Important to Safety

As noted in Table 8.2-2 and the discussion above, it is unlikely that ash fall events will deposit 8 cm of ash or more at the ISF Facility site. However, the design and construction of the ISF facilities, and the timeframe available to react to potential events, significantly reduces the consequences of such an event. The primary source of these events is likely to be the Cascade range, several hundred miles to the West. An extensive seismic network exists to monitor volcanic activity within the Cascade range. As noted in Section 2.6.2.1.2, a similar network exists at the INL to monitor potential near-field sources of volcanic ash. Therefore, volcanic activity that could potentially lead to an ash fall event is likely to be detected weeks before such an event. In the case of a Cascade eruption, several hours will also pass between the eruption and the arrival of an ash cloud at the ISF Facility site.

The potentially affected ISF structures, systems, and components (SSCs) important to safety (ITS) have been designed to perform their safety-related functions in a passive mode; no operator intervention or outside resources are required. In the case of an emergency facility shutdown (on the order of minutes), facility equipment has been designed to fail in an as-is condition, allowing the facility to be evacuated. With only a few hours warning, the facility can be readily placed in a standby condition where only minimal building services and limited monitoring are required for an extended period of time.

The SSCs most likely to be impacted by an ash fall event are the facility structures, facility ventilation system, and the storage area decay heat removal system.

Facility Structures. The facility structures have been designed for a minimum roof snow load of 30 lbs/ft^2 (see Section 3.2.4). Assuming that the deposited ash has a density on the order of 50 lbs/ft^3 (approximately ½ that of typical in-place soil densities), the design snow load would bound ash falls of up to 0.6 ft, or 18.3 cm. Ash deposits of this thickness far exceed those that are anticipated to occur at a probability level of 10^{-6}/yr. Therefore, facility structures are anticipated to withstand loads due to ash deposits for all credible ash fall events.

Facility Ventilation System. With the exception of certain passive components, the main facility ventilation system is not considered important to safety, and can be secured during an ash fall event. The impacts of securing the facility ventilation system are bounded by the impacts described for a ventilation system failure in Section 8.1.5.1. The ITS SSCs within the facility ventilation system consist of ducts, dampers, and HEPA filters, all of which are protected from exposure to ash by the facility structure, upstream filters, and/or isolation dampers that can be closed. Therefore, ITS SSCs within the facility ventilation system are anticipated to be able to perform their safety function during and after an ash fall event. Recovery activities would include contamination surveys; ash removal and decontamination as required; changing filters as required; and verifying that all HVAC equipment and instrumentation was operating properly.

Storage Area Decay Heat Removal System. Sections 8.1.3.5 and 8.2.4.1 discuss the impacts of substantial blockage of the inlets to the heat removal system. Note that this analysis is equally applicable to substantial blockages of the outlets to the heat removal system (e.g., annular gaps around the top of individual storage tubes). The data presented in these sections indicate that storage area temperatures are maintained within acceptable ranges indefinitely with up to a 50% reduction in air flow through the storage vault. This degree of blockage is highly unlikely, given the size and positioning of the inlet air vents, and the fact that the annular gaps around the storage tubes are covered by the storage area structure (see Figures 4.2-4 , 4.3-2, 4.3-8, and 4.3-9). Airflows are also directed up and out through these annular gaps, further reducing the probability that they may be blocked by ash. Even under hypothetical adiabatic conditions, over nine days would elapse before storage area temperatures exceeded the off-normal temperature limits for the concrete. This provides more than adequate time to address potential blockage of the air outlets (e.g., vacuuming the charge face). Therefore, the storage area heat removal system is anticipated to be able to perform its safety function during and after an ash fall event.

Radiological Consequences

Based on the surveillance requirements, the accumulation of ash fall and the blockage would be noted and removed, eliminating even a 50 percent vent blockage case. The Storage Area's ability to maintain adequate heat transfer (and therefore, geometry, confinement, and shielding) of the stored fuel would not be impaired. There would be no radiological releases and no radiological consequences from this event.

This event involves no change to the fuel or structural integrity configuration. Therefore, there is no change to the criticality, confinement, or retrievability of the SNF

8.2.5.8 Aircraft Impact

Cause of Accident

Section 2.1.2 describes the location of airports near the ISF Facility. Control of these aircraft are outside of the influence of ISF Facility personnel and the possibility of a crash on the site must be considered.

Accident Analysis

As described in Section 2.2, aircraft impact probability evaluations for the ISF site and INTEC facilities (Ref. 8-27) have been performed. For both situations, these facilities satisfy each of the three requirements in NUREG-0800, Section 3.5.1.6, Aircraft Hazards (Ref. 8-28) that allow the applicant to determine by inspection that the probability of aircraft accidents resulting in radiological consequences greater than 10 CFR 100 exposure guidelines is less than 10^{-7} per year. Therefore, this event is not considered credible.

Radiological Consequences

This event is not considered credible; therefore, no radiological consequences are postulated as a result of aircraft impact.

8.3 SITE CHARACTERISTICS AFFECTING SAFETY ANALYSIS

The ISF Facility site location is depicted in Figures 2.1-3 and 2.1-5. The installation is designed for storing 246 ISF canisters in storage tubes and the facility layout is shown in Figure 2.1-11. The storage tubes are supported by a thick concrete charge face and a passive air circulation system for cooling. The controlled area for the ISF Facility is also shown in Figure 2.1-11. The ISF site is isolated from population centers and is located in a controlled restricted area of the INL site. Figure 2.1-3 shows the accessibility of the site to truck and rail transportation.

Site characteristics that affect the safety analysis are summarized in Table 8.3-1.

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Table 8.1-1 **Sheet 1 of 3**
Off-Normal Events Evaluated

Section No.	Description	Estimated Dose (mrem)	Detection	Cause	Corrective Action	Effects and Consequences
8.1.1.1	Misventing of Transfer Cask	Less than 10 mrem to operator. Negligible at controlled area boundary.	Visual inspection, fixed radiation monitoring, or health physics monitoring.	Operator error or equipment failure.	Decontaminate area, determine cause and implement corrective action.	Increased dose inside Transfer Tunnel.
8.1.1.2	Cask Drop Less Than Design Allowable Height	No radiological consequences.	N/A	Not a credible event.	N/A	N/A
8.1.2.1	Attempt to Lower Fuel Container Into Occupied Fuel Station	No radiological consequences.	Visual inspection, load indication, or trip of FHM on slack rope.	Operator error.	Determine cause and implement corrective action.	No adverse consequences.
8.1.2.2	Attempt to Load Fuel Element Into Full ISF Basket	No radiological consequences.	Visual inspection, load indication, or trip of FHM on slack rope.	Operator error.	Determine cause and implement corrective action.	No adverse consequences.
8.1.2.3	Failure of Fuel Element During Handling	No radiological consequences outside of FPA area.	Visual inspection or fixed radiation monitoring.	Operator error or equipment failure.	Cease operations, recovery actions, determine cause, and implement corrective action.	Delay in operations while fuel recovery is performed.
8.1.2.4	Drop of Fuel Element During Handling	No radiological consequences outside of FPA area.	Visual inspection or fixed radiation monitoring.	Friction grapple failure.	Cease operations, recovery actions, determine cause, and implement corrective action.	Delay in operations while fuel recovery is performed.
8.1.2.5	Fuel Container Binding or Impact During Handling	No radiological consequences.	Visual inspection or FHM load indication.	Operator error or equipment malfunction.	Cease operations, recovery actions, determine cause, and implement corrective actions.	Delay in operations to replace ISF canister.
8.1.2.6	Malfunction of ISF Canister Heating System	No radiological consequences.	Temperature monitoring.	Equipment failure.	Repair or replace canister heater module.	Increase in fuel temperature, but no adverse consequences.

Table 8.1-1 Sheet 2 of 3
Off-Normal Events Evaluated

Section No.	Description	Estimated Dose (mrem)	Detection	Cause	Corrective Action	Effects and Consequences
8.1.2.7	Malfunction of ISF Canister Vacuum Drying/Helium Fill System	No radiological consequences.	Routine inspections.	Operator error or equipment failure.	Repair equipment, determine cause, and implement corrective action.	Delay in operations, possible increase in fuel temperatures, but no adverse consequences.
8.1.2.8	Loss of Confinement Barrier	Potential spread of particulate into adjacent areas of FPA. Non-mechanistic dose at the controlled area boundary is less than 0.02 mrem. (1)	Routine inspections of HVAC operations, fixed radiation monitoring, or health physics monitoring.	Failure of port seal, operator error, or HVAC system failure.	Repair equipment, determine cause, and implement corrective action.	Increased radiation dose to onsite personnel due to decontamination efforts.
8.1.3.1	Binding or Impact of ISF Canister During Hoisting/Lowering Operations	No radiological consequences.	Visual inspection.	Binding not credible. Operator error may cause minor impacts.	Determine cause and implement corrective action.	No adverse consequences.
8.1.3.2	ISF Canister External Contamination in Excess of Limits	Minimal dose consequences from decon efforts. 0.1 DAC	Routine inspection, fixed radiation monitoring, or health physics monitoring.	HVAC or other equipment failures, poor housekeeping, or operator error.	Decontaminate, determine cause, and implement corrective action.	Increased radiation dose to onsite personnel due to decontamination efforts.
8.1.3.3	Extended Operation with ISF Canister in CHM	No radiological consequences.	Visual inspection.	Equipment failure, operator error, or loss of power.	Repair equipment, determine cause, and implement corrective action.	Increase in fuel temperature.
8.1.3.4	Malfunction of Storage Area Vacuum Drying/Helium Fill System	No radiological consequences.	Visual observation of instrumentation for pressure indication.	Equipment failure or operator error.	Repair equipment, determine cause, and implement corrective action.	Increase in fuel temperature.
8.1.3.5	Partial Air Inlet/Outlet Vent Blockage	No radiological consequences.	Visual inspection.	Snow, ice, or windblown debris.	Clear obstructions from inlet/outlet.	Increase in fuel temperature.

(1) Note that the reported dose is a bounding dose from the Maximum Hypothetical Accident (Section 8.2.4.5), no Off-Normal event was evaluated.

Table 8.1-1 **Sheet 3 of 3**
Off-Normal Events Evaluated

Section No.	Description	Estimated Dose (mrem)	Detection	Cause	Corrective Action	Effects and Consequences
8.1.4.1	Breach of Waste Package in the Solid Waste Area	Minimal dose consequences from decon efforts. 0.1 DAC	Visual observation by operator performing operation.	Equipment failure or operator error.	Repair equipment, determine cause, and implement corrective action.	Increased radiation dose to onsite personnel due to decontamination efforts.
8.1.4.2	High Dose Rate to Solid Waste Area	Negligible worker exposure and no off-site consequences.	Fixed area radiation monitors and operator observation.	Operator error	Return material to FPA, determine cause, and implement corrective action.	Increased radiation level in unoccupied waste enclosure. Negligible worker exposure.
8.1.5.1	Ventilation System Failures	No significant release or exposure and no off-site radiological consequences	Observation of operation and instrumentation by operator	Equipment failure or operator error.	Repair equipment or determine cause, and implement corrective action	Increased fuel temperatures, no significant release, negligible worker exposure, no offsite exposure.
8.1.5.2	Loss of External Power Supply for a Limited Duration	No radiological consequences.	Visual observation by operator	External accidents, equipment breakdowns or malfunctions, or natural phenomena events	Restore power source. Manual and backup power available but not required.	Increased fuel temperatures.
8.1.5.3	Off-Normal Ambient Temperatures	No radiological consequences.	Observation of ambient weather	Sustained extreme ambient temperature conditions	None required. HVAC designed for extremes.	No adverse consequences.

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Table 8.2-1
Tornado Missile Barriers

Area	Confinement Boundary	DBT Protection	Analyzed Configuration
Onsite, outside Cask Receipt Area	Transfer cask	Transfer cask	Transfer cask/transport trailer
Onsite, inside Cask Receipt Area	Transfer cask	Transfer cask	Transfer cask/transport trailer
			Transfer cask/cask receipt crane
	Transfer cask	Transfer cask/cask trolley system	Transfer cask/cask trolley system
Onsite, inside Transfer Tunnel	Transfer cask	Transfer Tunnel structure and outer tunnel door over opening	Transfer Tunnel concrete and outer tunnel door
	ISF canister	Transfer Tunnel structure and outer tunnel door over opening	Transfer Tunnel concrete and outer tunnel door
FPA	FPA boundary, HVAC HEPA filters, inflatable seals on cask and canister ports, sides and bottom of Transfer cask and ISF canister when FPA shield plug removed and seals inflated, shield windows	FPA structural concrete, local protection of HVAC tornado dampers and intervening ductwork, outer tunnel door, and shield window structure	FPA structural concrete, HVAC tornado dampers and intervening ductwork, outer tunnel door, and shield window structure
CCA	Transfer Area boundary, ISF canister	Transfer Area structure, and low probability on viewing window opening	Transfer Area structure, and low probability on viewing window opening
Storage Area	Storage tubes and ISF canisters	Storage Area structure, including charge face, port plugs, and tube cover plate.	Storage Area structure, including charge face, port plugs, and tube cover plate.
SWPA	Solid Waste Storage Area	None required due to low probability and acceptable dose consequences	Postulated dose consequences are acceptable without protection

Table 8.2-2
Probabilities of Various Volcanic Ash-Producing Events That May Affect the ISF Facility Site

Scenario	Approximate Annual Probability of Given Scenario	Reference
Silicic eruption with in tens of kilometers of proposed site	less than 4×10^{-6}	8-36
Local silicic eruption producing ash-fall affecting proposed site	10^{-7}	8-35, 8-36
Basaltic eruption within tens of kilometers of site (this type of eruption is unlikely to produce ash)	3×10^{-5} to 4×10^{-6}	8-36
Basaltic eruption producing ash-fall affecting proposed site	less than 10^{-7}	8-36, 8-37
Ash-fall from volcano 100-400 km from site (Yellowstone)	2×10^{-6}	8-30, 8-36
Ash-fall from Yellowstone greater than 8 cm thick at proposed site	10^{-7}	8-30, 8-38
Ash-fall from Cascade volcano of 1 cm or more at proposed site	5×10^{-3}	8-34
Ash-fall from Cascade volcano of 10 cm or more at proposed site	10^{-6}	8-34
Ash-fall from Cascade volcano greater than 8 cm at proposed site	10^{-6}	8-34, 8-39, 8-40

Table 8.3-1
Site Characteristics That Affect The Safety Analysis

Site Characteristic	Values Used	Addressed in SAR Section
Temperatures	Accident ambient extremes: -40°F to 101°F	8.1.5.3
Seismic loads	0.123g horizontal at bedrock	8.2.5.2
Precipitation	Combined with Mackay Dam failure, see Flooding	8.2.5.3
Flooding	Approximately 4921 feet (MSL NAVD 88 Datum)	8.2.5.3
Wind loads	200 MPH with a 1.5 psi pressure drop	8.2.5.4
Missile loads	115-pound wooden plank at 190 feet/sec 287-pound 6-inch diameter steel pipe at 33 feet/sec 9-pound 1-inch diameter steel rod at 26 feet/sec	8.2.5.4

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Figure 8.2-1
INTEC Area Maximum Dose for Non-Mechanistic Accident

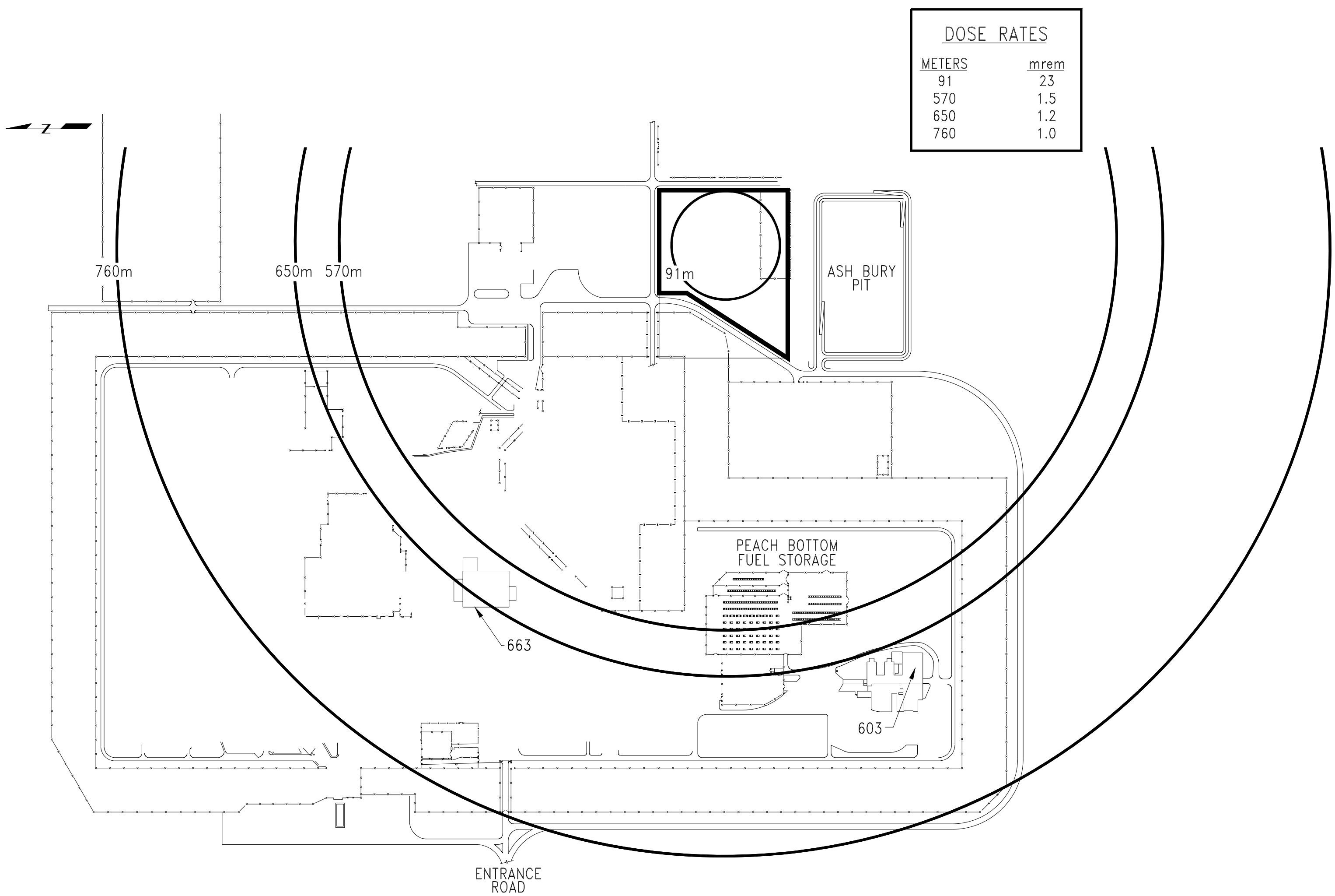

Figure 8.2-2
INL Area Maximum Dose For Non-Mechanistic Accident